

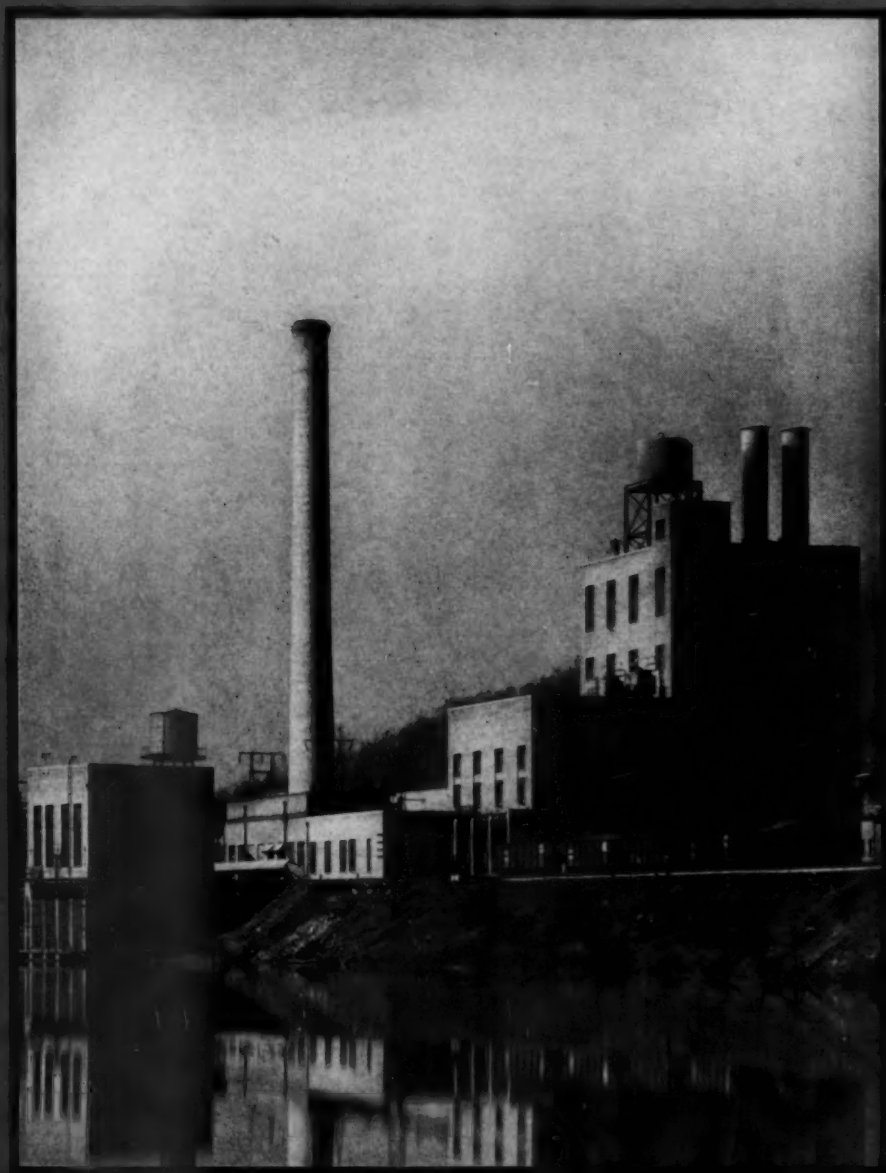
COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

Vol. 11, No. 1

JULY, 1939

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Extension to Cumberland Station; stack in center serves old plant

**Economic Features of Cumberland Plant Addition,
The Potomac Edison Company**

Application of Glass Electrode to pH Determinations

Brimstown—England's First 2000-Lb Installation

6 months of Continuous Service

C-E EQUIPPED STATION SETS RECORD FOR HIGH PRESSURE UNITS



Boiler furnace photographed after completion of 6-months' run and before cleaning.

Another record for Wisconsin Electric Power Company's Port Washington Station and another instance of the high availability of C-E's high-pressure steam generating equipment. The world's most efficient steam power station in 1936, 1937 and again in 1938, the Port Washington Station has now established a remarkable record for continuous service. In operation for 24 hours every day, seven days every week, it had been "on the line" continuously for six months and five days on April 22, 1939, the date for a scheduled outage period for cleaning and inspection.

The C-E high-pressure unit which participates in this record-making and which supplies all the steam at Port Washington was designed to produce 690,000 lb of steam per hour at 1325 lb pressure and 830 F total temperature.

Excellent overall performance at Port Washington and throughout all the plants of the Wisconsin Electric Power Company was emphasized by The Prize Awards Committee



Port Washington, the low-cost generating station of Wisconsin Electric Power Company.

HIGHLIGHTS OF PORT WASHINGTON'S CONTINUOUS OPERATION

October 17th, 1938 to April 22, 1939

Hours of Service	4,484.75
Power Generation in Kw Hr	239,282,000
Coal Consumption in Tons	94,163.3
Pounds of Steam Generated	1,786,810,000

MAXIMUM OUTPUT

80,000 Kw	690,000 lb of steam per hr
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MINIMUM OUTPUT

17,000 Kw	160,000 lb of steam per hr
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AVERAGE OUTPUT

53,315 Kw	398,400 lb of steam per hr
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of the Edison Electric Institute in their selection of Wisconsin Electric Power Company by unanimous vote to receive the coveted Charles A. Coffin Award for 1938.

Successful performance of C-E equipment is not a new experience at the Wisconsin Electric Power Company. At the Lakeside Station, 3 C-E high-pressure boilers installed in 1929 and 1930 showed an availability record of 96.3 per cent covering a period of four years. Prior to that, and as early as 1920, C-E pulverized fuel burning equipment was installed under various units in the plants of the Wisconsin Electric Power Company.

C-E is proud to have so much of its equipment in the service of Wisconsin Electric Power Company which, to quote the Prize Awards Committee of the E.E.I., "has made distinguished contributions to the technical development of this industry in efficiency, power generation and in power sales to the public."

A-458

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COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

VOLUME ELEVEN

NUMBER ONE

CONTENTS

FOR JULY 1939

FEATURE ARTICLES

Economic Features of Cumberland Plant Addition, The Potomac Edison Company	by James F. Muir.....	24
An Improved System in the Application of Non-con- densing or Extraction Turbines	by H. W. Cross and E. S. Wells, Jr.....	32
Bituminous Coal Prices Announced.....		35
Brimstown—England's First 2000-Lb Installation.....		37
Application of the Glass Electrode to pH Determinations	by R. T. Hanlon.....	41
Laying Up Boilers for Protracted Outage.....		47

EDITORIALS

Outmoded Terms.....	23
British Practice Forging to the Front.....	23
Time for Bringing Up and Taking Out Boilers.....	23

DEPARTMENTS

Steam Engineering Abroad—Underground Power Station, Burning Pitch in Pulverized Form, Italian Motor Plant Employs High Pressure, Burning Pea and Duff in Layers on Chain Grates.....	44
New Catalogs and Bulletins.....	46
Advertisers in This Issue.....	48

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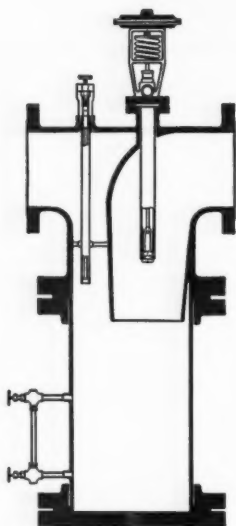
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The COPEs DESUPERHEATER



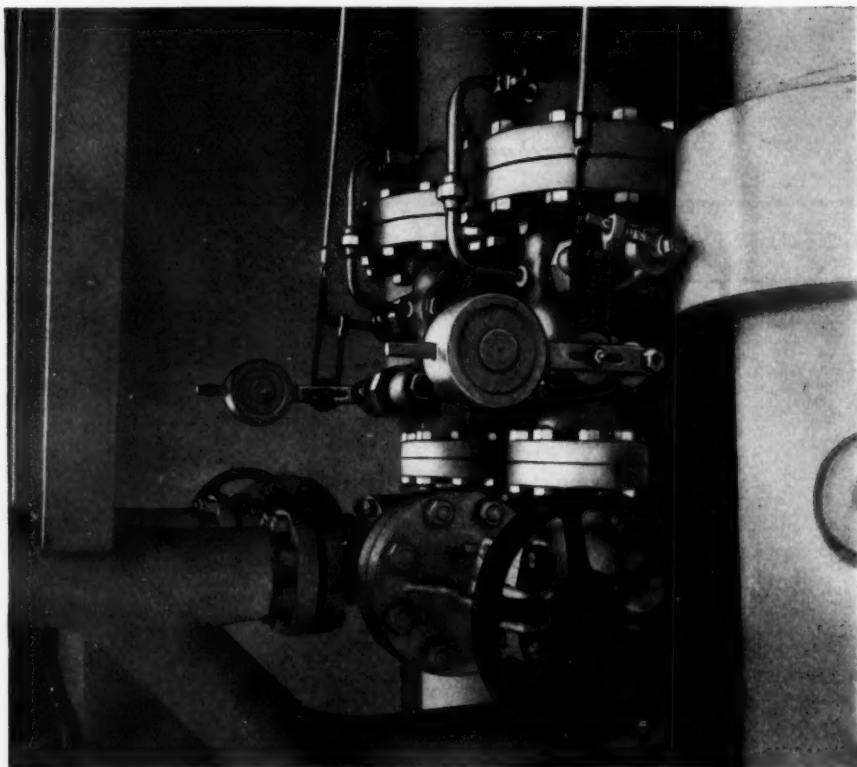
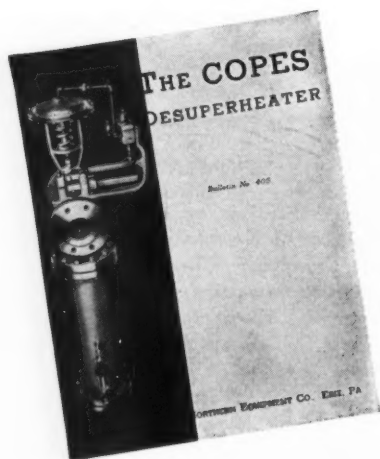
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EDITORIAL

Outmoded Terms

As power plant practice advances it becomes necessary, from time to time, to revise our concepts as expressed by certain terms. This is especially true as regards the capacity and performance of steam generating units.

In the days when steam engines utilized most of the steam produced by boilers it was convenient to rate both in the same units. This led to the term "boiler horsepower" which was defined as the evaporation of thirty pounds of water at one hundred degrees Fahrenheit into steam at seventy pounds, on the basis that the average engine of good design required about thirty pounds of steam to produce a mechanical horsepower. This was later standardized by the American Society of Mechanical Engineers to thirty-four and one-half pounds equivalent evaporation "from and at" two hundred and twelve degrees Fahrenheit. Although boiler horsepower is meaningless today, the term is dying hard and is still used to a limited extent in the trade with reference to small units. It also often creeps into statistics and surveys.

The next step was an attempt to correlate boiler horsepower with design calculations by adopting ten square feet of heating surface as capable of producing a boiler horsepower. This was based on the results of numerous tests on boilers of the conventional design such as prevailed twenty years or more ago. The trend in modern steam generating units, however, has been toward an ever-decreasing proportion of convection heating surface and increasing surface in furnace water walls, superheaters, economizers and air preheaters. So here again, the term has become outmoded as a measure of output.

With the general adoption of turbine-generators it became convenient to define the output of steam generating units in terms of thousands of pounds of steam produced per hour at the given steam conditions. For direct conversion into kilowatt-hours output of the prime mover this is convenient and is quite generally employed, but as a means of comparing the performance of steam generating units it is unsatisfactory. Output in "millions of Btu per hour" is a more satisfactory term for this purpose and is prescribed in the Test Codes.

A term that has been widely used in recent years to denote furnace loading is "Btu heat release per cubic foot of furnace volume." While it gives an indication of comparative furnace sizes for a given output, it is not a measure of furnace performance, because the total heat absorbed in the furnace is a function of the exposed water-cooled surface. A much more satisfactory basis is "Btu released and absorbed per square foot of projected radiant surface." This is now being employed by many designers of steam generating units and some operating companies, but it has not yet widely permeated the field.

It takes time for engineering terms to receive general acceptance and still longer for them to be discarded after they have outlived their usefulness.

British Practice Forging to the Front

British practice has generally been regarded as conforming to conservative lines and following rather than leading American practice in the widespread adoption of high steam pressures, high temperatures, large units and topping installations. For this British engineers are not to be criticized, as conditions in many cases are not comparable. However, within the last two or three years, during which power plant construction in England has been most active, there have been indications of breaking away from the former conservatism.

Turbine-generators of fifty and sixty thousand kilowatts capacity are no longer unusual, and one of a hundred thousand kilowatts is being installed. A steam generating unit of five hundred thousand pounds capacity at thirteen hundred and fifty pounds pressure and nine hundred and fifty degrees Fahrenheit total steam temperature is nearing completion at Battersea Station; a large La Mont forced-circulation boiler has lately gone into service at Deptford West Station; and two Loeffler units for two thousand pounds pressure have just been completed at Brimsdown. Two similar, but larger, units are on order.

The description of the Brimsdown units, which appears elsewhere in this issue, is of particular interest, not only because of their unconventional design as compared with American practice for high-pressure service, but also because of certain construction details. Furthermore, the high thermal efficiency of over twenty-nine per cent that has already been attained, during the initial period of operation, promises to place Brimsdown in the front rank of British power stations.

Time for Bringing Up and Taking Out Boilers

Operating practice appears to vary considerably as to the time for putting a high-pressure boiler on the line from cold condition, and also that required to take it out of service. In some cases units are brought up to full pressure, from cold, in two hours, or slightly less, whereas in others double this time is customary. This applies to natural-circulation boilers of the more-or-less conventional type and not to certain special European designs for which claims of very much shorter periods have been made. Obviously, a boiler can be brought up to operating conditions in much less time than it can be brought down because the tubes, being thinner than the drums and headers, take up the temperature of the water more quickly and tend to expand; but the reverse is true in taking a unit out of service and if it is brought down too rapidly leaks are likely to occur at the joints.

While local conditions and the type of unit may have some bearing, the problem is one that warrants further determination.

Economic Features of Cumberland Plant Addition, The Potomac Edison Co.

By JAMES F. MUIR

American Water Works and Electric Company

A review of the considerations that led to the selection of a single-boiler, single-turbine installation and steam conditions of 825 lb pressure and 825 F total steam temperature. The main features of the plant are described and performance curves are included. From July 1, 1938, when the plant became commercially operative, to June 30, 1939 the service availability has been 92.93 per cent.

THE Potomac Edison Company of Maryland, owner of the Cumberland Station, is one of a group of three operating companies which form the integrated system of the American Water Works and Electric Company. The operating associates are the West Penn Power Company in western Pennsylvania and the Monongahela West Penn Public Service Company in northern West Virginia.

Historical Outline of Potomac Edison System

In the early period of electric operations, the Potomac Edison system consisted of two major isolated territories in Maryland, one in the central section of the state, together with adjacent districts in Virginia and Pennsylvania, and with operating headquarters at Hagerstown, Md.; the other covered the entire western part of the state with the load concentrated, for the most part, at Cumberland. These respective districts in 1922 were served principally by three low-pressure steam plants, each about 9000 kw, and small run-of-river type hydro stations totaling about 5000 kw. The combined peak of the two systems was less than 25,000 kw. By 1937 the system load had mounted to 70,000 kw, representing an increase of almost 300 per cent in fifteen years.

The first step in the development and modernization of the Potomac Edison system to overcome an altogether inadequate capacity situation in the Hagerstown district, was the construction in 1923 of the Williamsport steam plant with an initial unit

rated at 15,000 kw. In 1927 a second unit of 30,000 kw capacity was installed.

The Williamsport project became the nucleus of a local plant for integrating the separated territories of the company and a broader program toward integrating the Potomac system and its western affiliated companies. The plans included the construction of a 66-kv transmission tie between Williamsport and Cumberland in 1927, and the installation in 1931 of a 132-kv interconnection between the Cumberland Station and the substation at the Lake Lynn hydro plant of the West Penn system. These interconnections established a two-source supply to the Cumberland district equivalent to a firm power capacity of 25,000 kw.

Prior to 1927 the eastern Maryland, or Hagerstown division, with its adjacent sections in Virginia and Pennsylvania, was the important center of load development, but by 1930 the Cumberland district, which now includes adjoining sections of West Virginia, began to experience a much more active participation in industrial expansion. In fact, during the period in which most central-station systems were experiencing a severe recession in load, the Cumberland load increased from 14,000 kw in 1931 in yearly increments of growth, to approximately 28,000 kw in 1937.

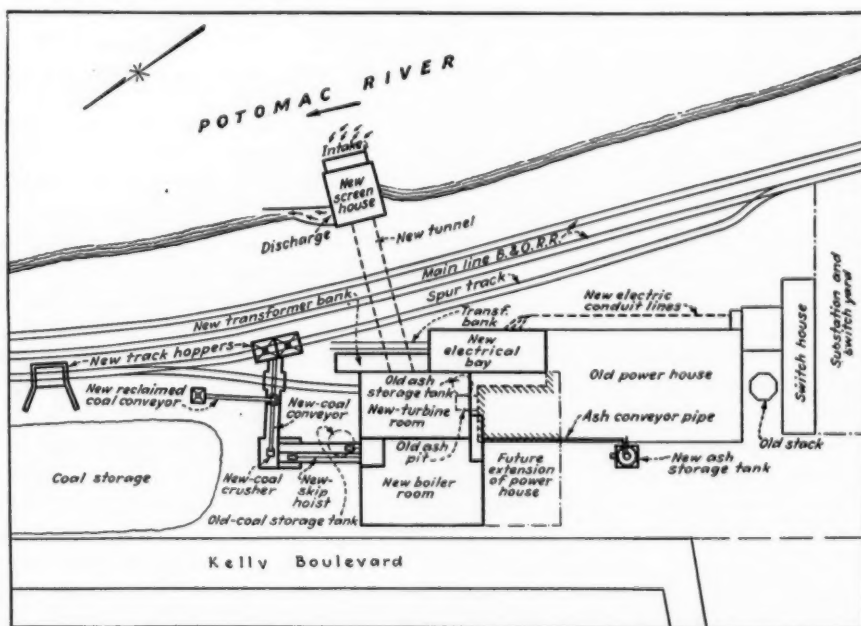


Fig. 1—Lot plan showing old and new plants

The original Cumberland Station with 9000 kw in low-pressure capacity was backed up by the Williamsport tie line and the interconnection with the West Penn system already mentioned. While these interconnections were reliable as regards the delivery of power, it is desirable and often necessary to provide adequate power generating facilities in districts where power requirements are supplied to important industries, and in general, for local load protection.

It became apparent by the end of 1936 that within

the old station. This area fitted to best advantage the requirements of a single boiler plant. Furthermore, because of the intervening B. & O. right-of-way, circulating and general service pumps were installed in a combination pump and intake house, located on the river bank. A 13-ft diameter tunnel connecting the pump house and the condenser room of the power station serves as a conduit for circulating and service water lines, as well as an operators' passageway between the two separated structures.

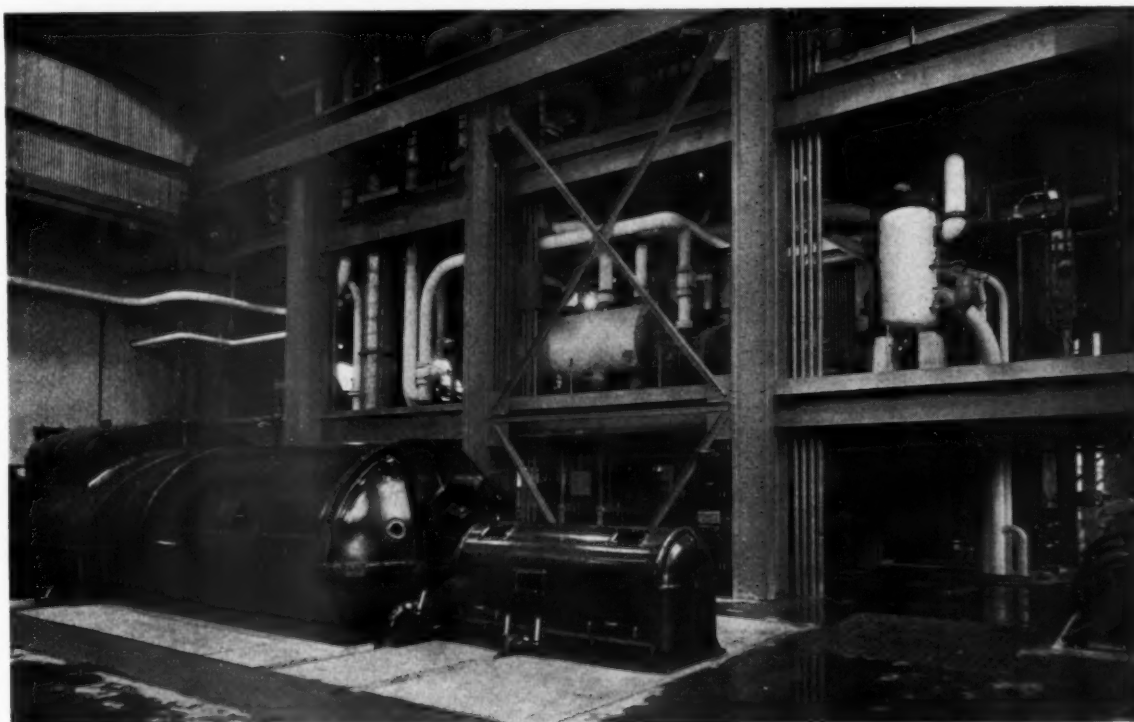


Fig. 2—Interior of plant from turbine room showing open arrangement

a comparatively short time system capacity reserves would be entirely exhausted, and to avoid an acute shortage of capacity in the Cumberland district, the necessary preliminary work of selecting the size and the operating characteristics of the proposed plant was inaugurated early in 1937.

The engineering design and construction was carried out rapidly by Sanderson & Porter of New York and the plant was completed in June 1938, requiring less than 12 months for actual construction.

Physical Features of Plant Property

The Cumberland plant is located on the north branch of the Potomac River, about two miles upstream from the city of Cumberland, Md. The property consists of a long-sided triangle, with a base at the west end about 300 ft in width. The B. & O. R. R., running east and west along the river bank, separates the plant property from the river with a right-of-way about 100 ft in width. The north side of the triangle is bounded by a main highway. The lot plan and general arrangement of the old and the new plants are shown in Fig. 1.

Leaving the old plant intact for needed reserve and active standby service, the space available for the new building and equipment consisted of a section of the yard about 140 ft in width beyond and adjacent to

While the physical features of the station property had considerable bearing on the selection of a single boiler, economic factors such as first cost, operating and maintenance expense, plant availability, all as discussed later on, were largely responsible for the adoption of the single-unit type of installation. The interior view of the new building, Fig. 2, shows the modern open-type arrangement of the turbine and boiler room.

Steam Conditions

In developing comparative economic results for units of different size, it is necessary, as a first step, to establish plant steam characteristics. For the 20,000 to 30,000 kw sizes under consideration, and taking into account the price of fuel delivered at the plant, pressure and temperature conditions ranging from 650 lb, 825 F to 1200 lb, 900 F, were investigated.

It was questionable whether 1200 lb, 900 F would be desirable or practical on these relatively small sizes of turbines. The specific volume of steam is so low at the higher pressure that difficulties in design, construction and assembly are encountered in providing adequate and proper steam flow areas through the high-pressure section of the machine, and relatively large losses may be looked for on account of the small size of buckets that must be used in a small machine designed for condensing opera-

tion and for conditions in the higher regions of pressure and temperature. At the time the analysis was in progress, namely, the winter of 1936-1937, no units of the condensing type had been built or were on order in sizes 25,000 kw and below, for operation with steam at

the higher pressure machine would be higher. It was believed that the availability would be lower on account of the greater precision in operating clearances, and the higher pressure and temperature operation. The cost of the 1200-lb turbine-generator would have been about 14 per cent higher than the 825-lb machine. Boiler, piping, etc., would likewise be higher in cost.

Early in 1937 when these matters were being studied, the turbine manufacturers were building a number of 825-lb, 825 F units the designs for which had been worked out and established. Also, deliveries on machines of this design were much more favorable. For a 1200-lb unit of such relatively small size, new development activities would have been necessary and the Potomac unit would have been the first of this condensing type.

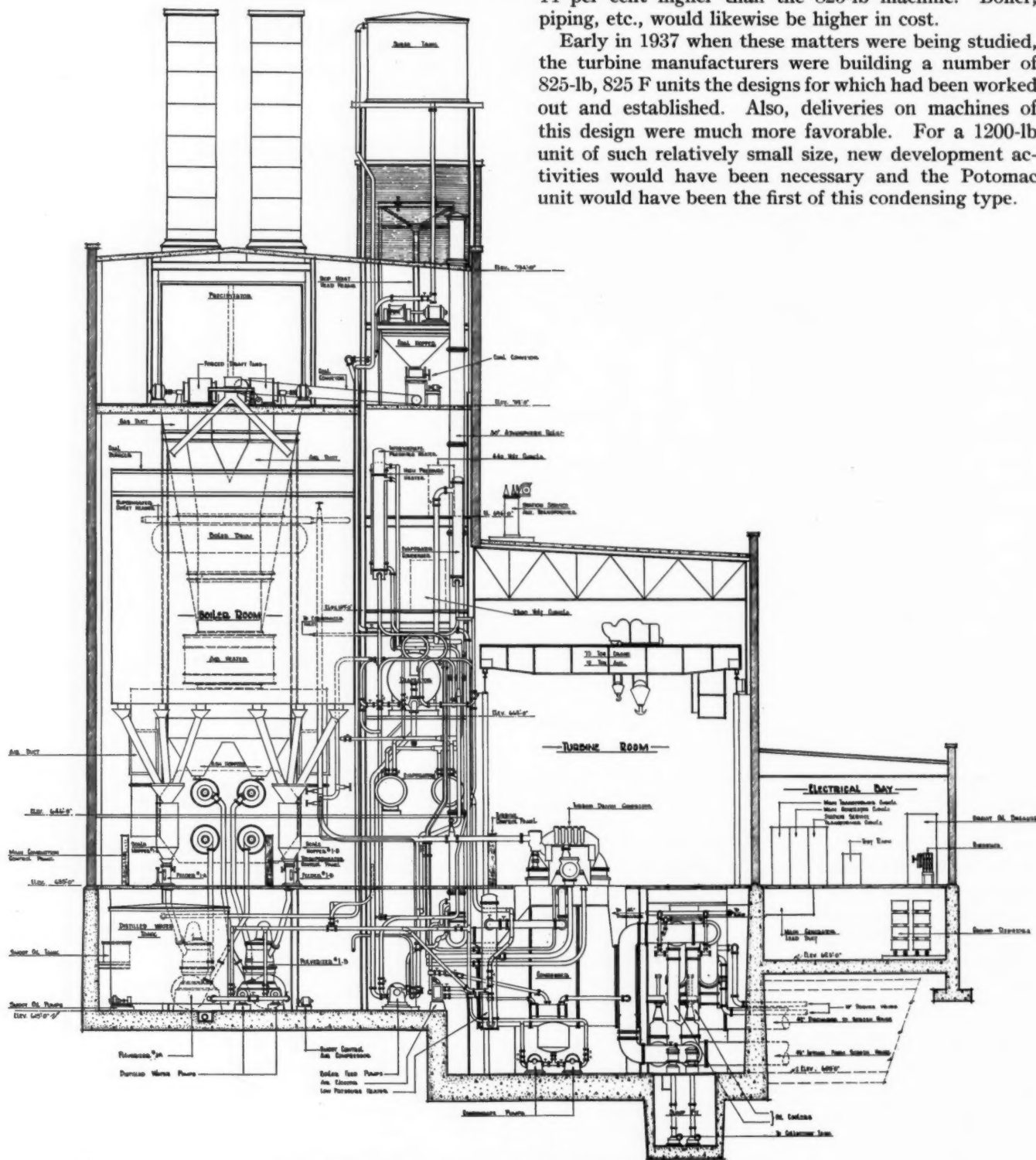


Fig. 3—Cross-section through Cumberland Plant extension

1200 lb, 900 F. However, machines for these conditions could have been built, and the overall gain in economy with 1200 lb, 900 F, as against the next lower standard of 825 lb, 825 F, would be in the order of approximately 4 per cent. This advantage in economy would be offset by other costs and conditions. The maintenance of

Back-pressure machines as small as 4000 kw have been built for 1200 lb, 700 F exhausting at 350 lb. The 25,000-kw turbine at the Rivesville Station of the Monongahela system, for example, is a topping-type unit, designed for operation at 1200 lb, 900 F but exhausts at 260 lb. On the other hand, Potomac conditions called

for expansion of the steam to 29 in. vacuum. The vast difference in exhaust conditions which affect particularly the blade lengths and cross-section is revealed by the fact that a pound of steam at the exhaust in the case of the Rivesville unit will have a volume of 2.28 cu ft per lb, whereas for Potomac a machine with the same throttle pressure, would require the specific volume of the steam at exhaust to be 652.0 cu ft per lb. The result of the study showed that even if a 1200-lb, 900-F condensing unit of 25,000 kw or 30,000 kw could have been furnished at that time, it was apparent that with 14,000-Btu coal at \$3.25 per ton, the net gain in economy would not justify the greater first-cost for the higher pressure equipment. Accordingly, the 825-lb, 825-F standard was adopted. This also had more attractive economic possibilities than generating equipment in the 650-lb, 800-F classification.

Factors Influencing Capacity of Unit

The rated capacity, if the unit to be added under any system program of expansion, is related to the system requirements as a whole, and the problem of determining the most advantageous size, are subject to many variable factors and to the experience and judgment of the engineers concerned in the investigation. Briefly, the important factors include:

SPINNING RESERVE. This reserve is necessary to take care of active load fluctuations, system frequency regulations and emergency outages of major items of steam and electric generating equipment. This reserve, in general, is equivalent to approximately 10 per cent of the annual peak load, but may, under certain conditions, exceed this amount.

OUTAGE RESERVE. This factor takes care of normal outages of generating units and boilers for inspection or maintenance and reduction of hydro capacity due to low river flow. This allowance may be equivalent to the rated capacity of the largest unit or it may be equivalent to the sum of the two largest units, depending on size and character of system loadings.

RELAY CAPACITY FACTOR. This factor assumes importance and may be the controlling element in plant size determinations, since it affects directly the firm power capacity. In general, the new unit should relay or be equivalent to not less than the rated capacity of the largest unit in the system.

LOAD GROWTH RESERVE. This reserve is added to take care of the growth of the system and may be programmed either on a short-term or a long-term growth basis. The capacity extension may be undertaken to meet increased loadings forecast for anything from two to five years or longer. Included under this part of the investigation is the forecast of load growth, which by itself is a study of no small proportions.

POWER FACTOR COMPONENT. Since the rating of the turbine-generator is subject to change with change in power factor in determining the annual output in kilowatt-hours of the unit, the normal expectancy of output would be increased appreciably by an increase in power factor and would, therefore, affect the capacity of the addition and the economic results of the project.

CAPACITY SELECTED. All of the factors outlined in the foregoing serve as the background for economic analyses which must necessarily be developed to show the financial effect of various combinations of sizes of

turbines and generators for different steam pressure and temperature conditions. In the case of the capacity addition for the Cumberland Station, economic conclusions indicated that the Potomac Edison system would be served to best advantage by the installation of a generator of 30,000 kw capacity at 80-per cent power factor designed for 3-phase, 60-cycle, 11,500-volt operation, together with a turbine having a maximum rated capacity of 31,250 kw with steam at 825 lb, 825 F and a condenser of 25,000 sq ft.

Turbine and Generator Size Relationship

The Cumberland unit was built by the General Electric Company and consists of a 30,000-kw, 80-per cent power factor generator driven by a turbine of 31,250 kw maximum rated capacity. This differs somewhat from the standard capacity combination in that the turbine, which has a nameplate rating of 25,000 kw, would ordinarily be equipped with a generator of the same capacity rating.

Generators of modern design can now be depended on for stable operation up to unity power factor regardless of the power factor incorporated in the design of the machine. Accordingly, within certain design limits, the lower the power factor of the generator, the more the reactive kilovolt-amperes that can be absorbed under normal field temperatures. Other existing generators of older types on the system, under certain load conditions, may become moderately overheated due to low system power factor.

The question of installing, say, a 70-per cent as against an 80-per cent power factor generator involves consideration of the method to be employed in absorbing "line loss," or more technically "reactive kva." To establish the economic advantage of a 70-per cent power factor generator, it is necessary to determine the shortage of reactive kva capacity of the system and at the same time to develop possible plans for overcoming the effect of low system power factor.

With relatively low system power factor, economic improvement could be obtained by the operation of a 70-per cent power factor machine at the outgoing terminal of the transmission lines at the power station, or by installing capacitors or synchronous condensers at outlying distribution centers. A 70-per cent power factor generator is higher in cost than a unit of the same rating designed for 80 per cent, and, of course, at the same system power factor the 70-per cent unit will have a higher output capacity. Similar results as regards ability to absorb line loss due to low system power factor can be obtained by equipping the unit with an oversized standard generator of 80-per cent power factor rating. This in part explains the selection of the particular turbine and generator combination used for the Cumberland unit.

Turbine-Generator Design

The turbine is a 3600-rpm unit of the tandem-compound double-flow type. The high-pressure element consists of 18 stages and exhausts at about atmospheric pressure to the low-pressure section, which consists of three double-flow stages. The low-pressure shells, exhaust casing and cross-over connection are fabricated with steel plate, which type of construction has many economic advantages over the heavy cast-iron shells and exhaust casings previously employed for condensing units.

The turbine rotor is carried on three bearings of the ball-seated design, self-aligning, with pressure lubrication. The intermediate bearing between the high- and the low-pressure elements is inside the cross-over shell.

The turbine rotor consists of a solid alloy steel forging with all wheels machined integral with the shaft. This construction, as distinguished from the separately mounted disks, has been developed to meet the higher stresses which occur with 3600-rpm machines. Constructional details of the unit are shown in Fig. 4.

With a tandem-compound unit of this type, it is necessary, of course, to provide for separate shaft packings, two for the high-pressure end and two on the low-pressure sections. The packing on the throttle end of the machine comprises labyrinth teeth, leak-off space and impeller and housing for a water seal of the recirculating

ture limits in the armature and field. An exciter of 125 kw rating, with a 4-kw pilot exciter is driven through a reduction gear fitted to the end of the generator shaft.

Surface Condenser

The condenser as supplied by Foster Wheeler includes a two-pass unit containing 24,600 sq ft of surface made up of 4700 arsenical copper tubes, 1-in. O.D. No. 18 B.w.g. 20 ft long. For air-ejector service two 250-sq ft external air coolers are included. The tubes in the condenser are arranged with differential spacing on straight lines converging from the top and sides of the steam space toward the center and bottom of the shell. This design provides an actual steam lane of uniformly decreasing cross-section between each row of tubes. The general arrangement of the unit is shown in Fig. 5.

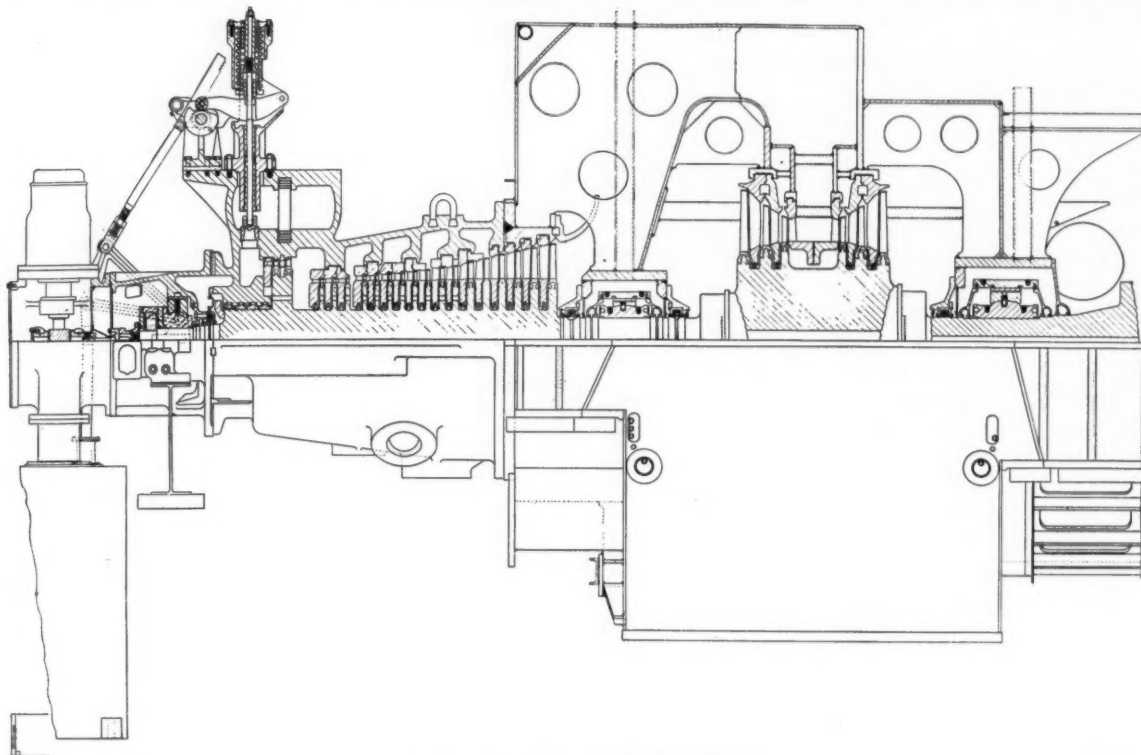


Fig. 4—Sectional view of turbine

type. The low-pressure ends are fitted with a leak-off space and impeller equipped with a water seal of the non-circulating type. In the latter case, water is added only to make up for loss due to evaporation. All four impeller casings are supplied from the same tank, elevated to give about 20 lb pressure at the unit. Provision is made also for supplying sealing steam to the packing leak-off space between the labyrinth and water seals, for sealing against air leakage when starting the unit. Leak-off from the packing gland at the throttle end is connected to the tenth-stage heater, operating at a pressure range of 18 to 66 lb absolute while the leak-off from the three low-pressure glands is piped to the eighteenth-stage heater, which operates under a pressure range of 2.5 to 9.5 lb absolute. The turbine is arranged for steam extraction at four points, all of which are utilized in the feed-heating system.

The 37,500-kva generator, designed for 3-phase, 60-cycles, 11,500 volts, at 3600 rpm, will deliver 30,000 kw at 80 per cent power factor at 5 per cent above and 5 per cent below rated voltage, without exceeding tempera-

The condenser shell is of copper-bearing rolled steel plate $\frac{3}{4}$ in. thick, with water boxes of cast iron. The turbine connecting piece is also of fabricated steel and is welded to the condenser and to the steel-plate turbine exhaust.

Tubes are rolled at both ends to $1\frac{1}{4}$ -in. Muntz metal sheets and to compensate for movements due to tube expansion and contraction, a stainless-steel diaphragm-type expansion point is provided at the return water box end of the unit. While a slight bow in the tubes would probably take care of tube expansion, the diaphragm has been included to prevent undue fibre stress in the tubing under abnormal temperature conditions.

An outstanding feature of the condenser is the central steam lane between the two centermost support plates, and directly under the exhaust-steam inlet, by means of which sufficient steam is delivered to the condensate heater to insure the highest possible condensate temperatures under all conditions of operation. The steam flowing down this center lane is prevented from dissipating into the tube bank and from condensing by means of two

vertically disposed baffle plates. This lane is open at the top between the centermost support plates but is, however, closed at the top in the other longitudinal sections to prevent short-circuiting of steam to the air cooler.

The condenser is of divided water-box construction and the water box covers are each made in two pieces so that the covers may be removed from one-half of the condenser and the tubes in that half cleaned while the other half is in operation. To obtain the maximum vacuum with one-half of the unit out of service, there is provided with this construction, an additional baffle extending horizontally the entire length of the steam space and vertically from the bottom of the hollow central baffle structure to the bottom of the condenser shell and to a point below the minimum water level in the hotwell. This effectively seals off each half of the

Circulating Water Temperatures 33 to 95 F

The supply of water from the Potomac River at the Cumberland Station site is subject to wide fluctuations in temperature, ranging from 33 F in winter to a maximum of 95 F during mid-summer periods, when river flow at times is almost at a standstill. A dam located about one mile downstream normally holds the river at an almost constant level and during extreme low flow periods considerable recirculation occurs resulting in the high injection water temperatures referred to above. The effect of these river water conditions is indicated in Fig. 8 which shows the station heat rates for winter and mid-summer conditions. While these curves are developed from guaranteed performance of units, actual operating records obtained since the plant was put in

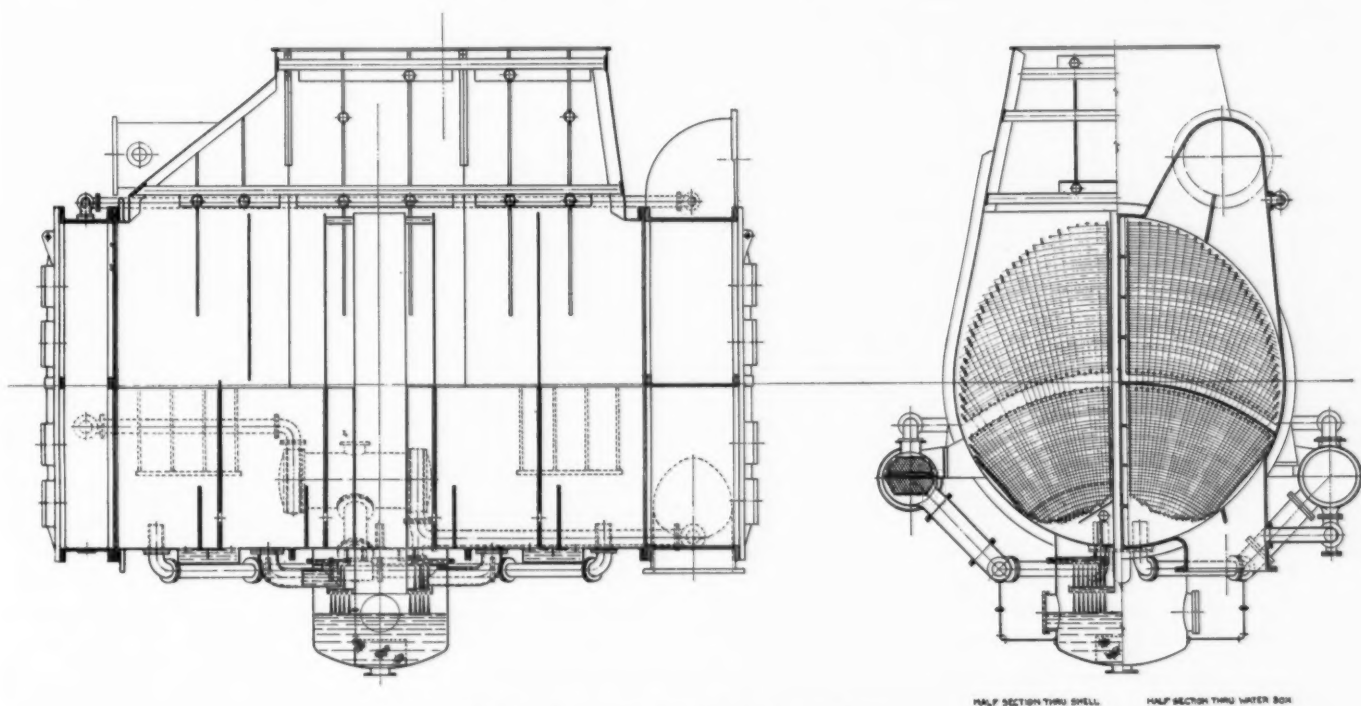


Fig. 5—Cross-section through condenser

steam space and prevents short-circuiting of uncondensed steam to the air cooler with one-half of the unit out of service.

The condenser is provided with four support plates which are tightly fitted to the shell and divide the steam space into five longitudinal zones. The air outlet from each zone is connected to a common offtake pipe which carries the air and non-condensable vapors direct to the air cooler. With the divided water box arrangement, there are two air outlets from each longitudinal zone and two air offtake pipes to the air cooler.

Auxiliary equipment consists of one steam-jet air pump comprising two two-stage elements, mounted on one surface inter- and after-condenser; duplicate hotwell pumps and circulating water pumps. The latter are vertical units of the axial-flow type and are located in the intake house, situated about 150 ft from the condenser. These pumps are driven by constant-speed vertical motors at 580 rpm and each has a capacity of 18,000 gpm for single operation and 31,000 gpm with two units in service. The height from pump base to motor base is 35 ft.

commercial operation late in the summer of 1938, have verified the rates shown at a number of points on the curves. With circulating water temperature of 50 F and below, a back pressure of $\frac{3}{4}$ -in. Hg can be maintained for long periods, while at 90 F, which is fairly normal during July and August, a back pressure of about $2\frac{1}{2}$ -in. Hg is anticipated.

One-Boiler vs. Two-Boiler Installation

In the preliminary consideration of boilers, it was tentatively suggested that two boilers might be installed with the first turbine-generator and one additional boiler with a future extension, resulting in an ultimate plant consisting of two 30,000-kw turbine-generators and three boilers. However, to meet these requirements, the initial two boilers, it was believed, should each have a capacity of approximately 190,000 lb per hr. This arrangement would have imposed an unnecessary burden on the initial project and was, therefore, abandoned.

The question of a single- or a two-boiler installation was influenced to a major extent by the power supply service provided by the Williamsport-Cumberland and

the West Penn interconnections. These interconnections are of sufficient capacity to supply the deficiency in output during outage of the single- or the two-boiler installation.

With a single-boiler plant, normal outages of boiler and turbine would be scheduled simultaneously. Intermediate interruptions or emergency outages should be of short duration.

With the two-boiler plant, it was considered unlikely that two boilers could be inspected and reconditioned during the scheduled turbine outage period. For this reason, annual power output might actually be lower with the two-boiler installation. The advantage of the two-boiler plant would occur if load conditions during week-ends permitted the shutting down of one boiler for minor repairs. This would seem to be of small consequence since boilers cannot be cooled sufficiently over Sunday to permit work of major importance being done. Two boilers would tend to avoid major interruption but these emergencies would, in the opinion of the engineers, hardly justify the increased cost of the two-boiler plant.

A further advantage offered by the single-boiler plant was that maintenance would be somewhat less than the two-boiler installation. There would be only one boiler to maintain, less piping, fewer valves, instruments and fans, and a much smaller building requiring attention of the maintenance force. Appraisal of the various factors mentioned above, and taking into account the desirability of conserving space on plant property of very limited area, resulted in selection of the single-boiler installation as meeting most suitably the particular set of conditions at the Cumberland plant.

Boiler and Combustion System

Current practice in the selection of fuel-burning systems for boilers of high capacity indicates a preponderant preference in the central station field for pulverized coal. Inasmuch as the steam generating unit for the Cumber-

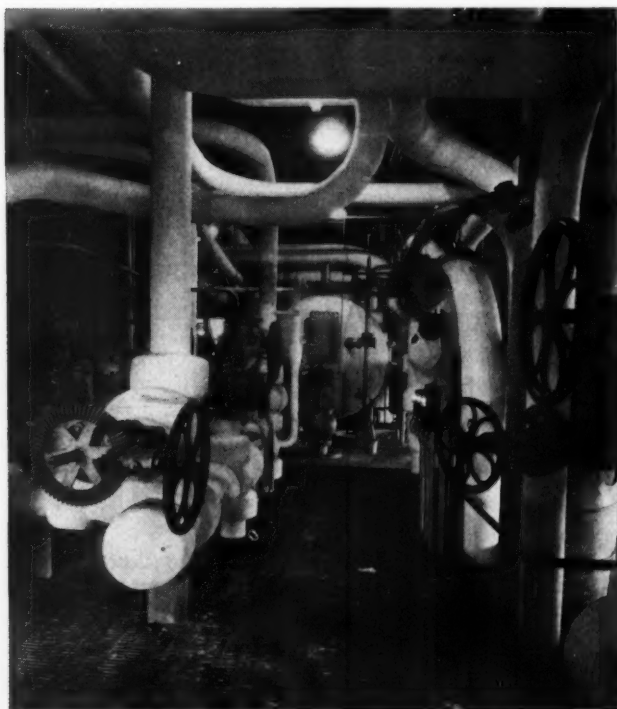


Fig. 6—View of pipe gallery

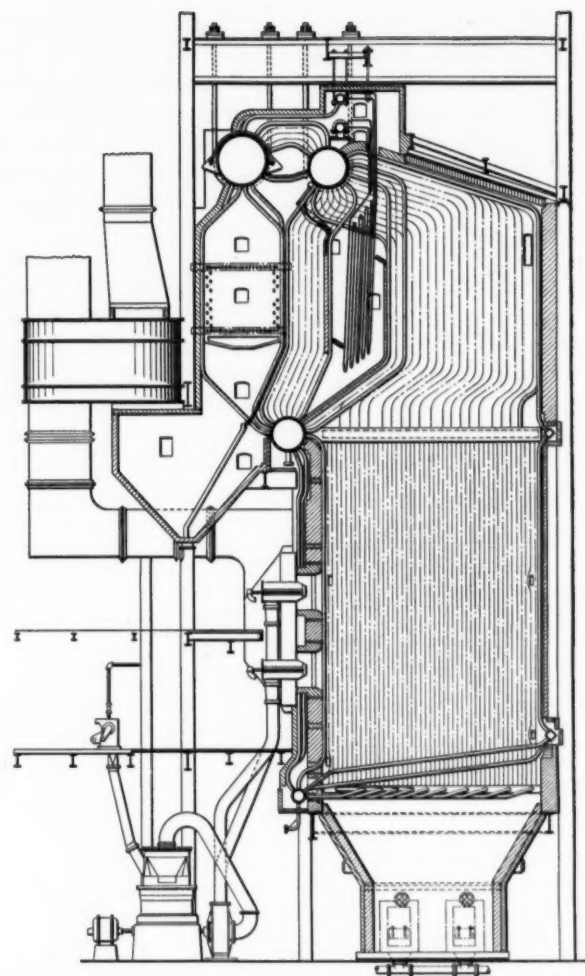


Fig. 7—Section through steam generating unit

land addition with a capacity above 300,000 lb per hr came under the high capacity classification, it was believed that pulverized coal firing held the most favorable economic and operating possibilities for this particular installation, and it was accordingly adopted.

With a permanent supply of high-grade coal available from the many mines in the neighborhood, having an ash-fusion temperature above 2700 F and a liquid temperature approaching 3000 F, the question of wet or dry bottom furnace was more or less automatically settled; and indeed, all designs offered and recommended in manufacturers' proposals included only the dry bottom design.

The boiler selected has a normal steaming rate of 312,000 lb per hr from feedwater at 350 F, and delivers steam at the superheater outlet at 825 lb pressure, 825 F temperature. The boiler, shown in cross-section in Fig. 7, including complete appurtenances, was designed and built by Combustion Engineering Company, Inc. It is of the C-E standard three-drum bent-tube type, with a water-cooled furnace of fin-tube construction on the lower front and side walls and plain tubes on the upper front, burner wall and bottom screen. The furnace is fired horizontally through the wall under the lower boiler drum, by means of four turbulent burners, each burner having a fuel oil unit for initial firing and lighting-off service. Pulverized coal is supplied by two C-E Raymond bowl mills. The unit includes an Elesco superheater and economizer, a Ljungstrom air preheater and a bubble-type steam washer.

A Cottrell curtain-rod type electrostatic precipitator between the air preheater and the induced-draft fans is provided to remove the fly ash from the flue gases discharged to atmosphere. Essential boiler auxiliaries comprising coal feeders and pulverizing mills forced- and induced-draft fans; also boiler-feed regulators are in duplicate to prevent, as far as possible, total interruption in steam output.

These duplications were not a physical or an operating necessity and their inclusion, therefore, brought about some increase in the first cost of the project. With a single boiler plant these units are in the same category as the duplicate hotwell and circulating pumps, which are usually provided with a single turbine-generator installation, and are believed essential to obtain maximum annual outputs and to hold the station in service during emergency outages of single units in the auxiliaries group.

Feedwater System

The feedwater system follows a more or less conventional regenerative design for straight condensing turbines, utilizing for heating service four stages of extraction. The first heater is supplied from the eighteenth stage with pressures varying from 5 to 10 lb absolute. A deaerator receives steam from the fourteenth stage at pressures varying from 10 to 35 lb absolute. The tenth stage, with a pressure range of 20 to 90 lb absolute, supplies steam to an evaporator and to a closed heater located in the heat cycle beyond the evaporator condenser. The final stage of heating is supplied to a heater from the sixth stage at an operating pressure of 40 to 200 lb absolute.

Plant Operation and Performance

Considering that the Cumberland high-pressure installation is of the single-boiler and single-turbine-generator type and the fact that outage of either major unit interrupts completely the output of the entire

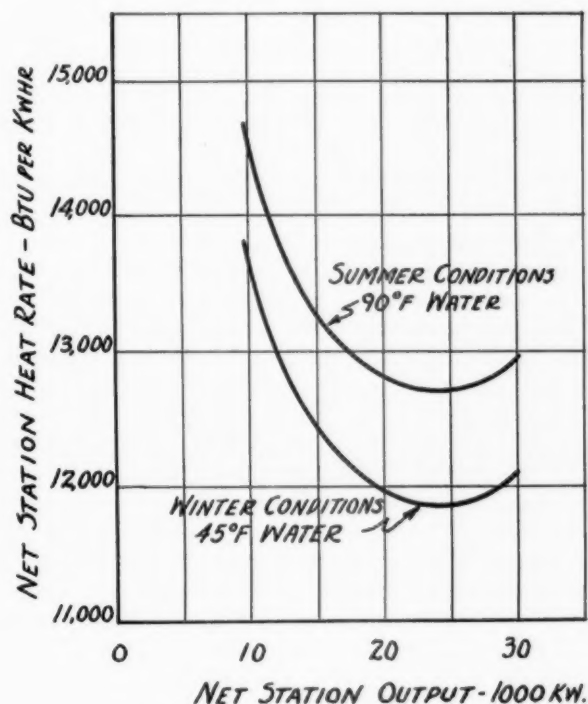


Fig. 8—Station heat-rate curves

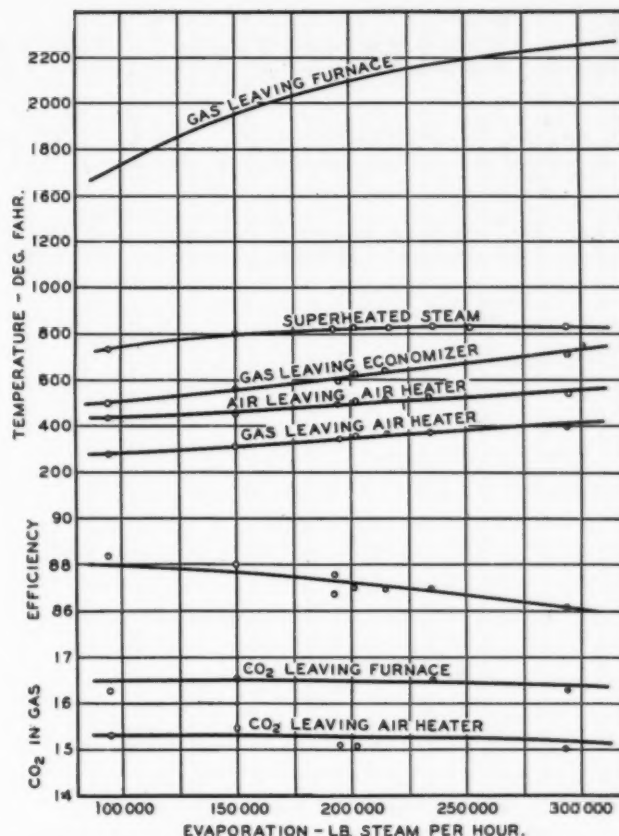


Fig. 9—Performance chart of steam generating unit

station, the availability for the initial period of operation has been quite satisfactory. From July 1, 1938, when the plant became commercially operative, to June 30, 1939, a period of 12 months, the actual service availability of the plant has been 92.93 per cent. The record for the year shows a total of fourteen plant outages, the longest one occurring in September 1938 and covering a continuous period of 129 hr. During this outage, work was done on the turbine, burners, boiler baffles and other miscellaneous work.

Improper assembly of the second baffle caused the longest outage of the boiler during March 1939, when this baffle was completely replaced, requiring five days for the work, which included also rebuilding of parts of the ash hopper. Raw coal feeders accounted for another outage, necessitating the replacement of drive mechanism for these units. Outside of some minor leaks in the high-pressure parts of the boiler and burner changes, the operation and performance of the boiler has been fully up to expectations. The unit has been free from slagging and any accumulations in the boiler and superheater tubes have been in the nature of dry fly ash or dust, which can be effectively removed by operation of ordinary soot blowers. Performance of the boiler is shown on the chart in Fig. 9.

The turbine-generator during initial operating periods developed some more or less minor vibrations, which were eliminated during a scheduled shutdown. The most troublesome operative condition of the turbine-generator was excessive noise and vibration on flat surfaces. These faults are being gradually eliminated, and the installation of stiffeners in the steel plate casing, exhaust connection, and some of the larger sections of the condenser shell during March 1939, has about cleared up these objectional occurrences.

An Improved System in the Application of Non-condensing or Extraction Turbines^{*}

By H. W. CROSS and E. S. WELLS, Jr.

General Electric Company, Chicago, Ill.

Since electrical output is definitely established by the energy drop between initial and exhaust conditions and by the quantity of steam flow, by increasing the total steam temperature at the throttle for a given pressure, the available energy is increased and consequently the electrical output. The application of a combined desuperheater and feedwater heater at the exhaust is shown to be advantageous in realizing gains from the use of higher temperature steam. Examples demonstrating the possibilities inherent in such systems are illustrated and explained.

It has been the practice in the application of non-condensing turbines and extraction turbines to choose a total temperature at the selected inlet pressure that will give the desired temperature at the exhaust or extraction opening of the turbine to suit the low-pressure system being served. As most applications are made in connection with old low-pressure turbine equipment, the design of which limits the temperature at which they may be operated, or process systems where little or no superheat is desired, the total temperature at the throttle for the new turbine is thus definitely limited.

A considerable gain in electrical output from the high-pressure, non-condensing portion of this cycle may be realized by increasing the total steam temperature at the throttle. However, an increase in initial temperature causes an increase in the temperature at the exhaust and may result in an exhaust temperature higher than desired. This gain in electrical output may be obtained if a desuperheater is installed on the exhaust system to reduce the temperature of the exhaust steam to suit the low-pressure system.

In systems of this nature, it is common to install a feedwater heater served by the exhaust steam from the high-pressure turbine, in order to obtain a greater electrical output by utilizing more heat from the exhaust steam, thereby increasing the flow of steam through the high-pressure unit.

As an improved system for realizing this gain by the use of higher steam temperatures, the application of a com-

bined desuperheater and feedwater heater at the exhaust is suggested. This would consist of two sections. One would be a surface-type heat exchanger, designed on a counterflow basis and arranged for free flow of exhaust steam through it. The other would be designed as a condensation-type feedwater heater.

The feedwater being returned to the boiler would be passed first through the heater section. If this section were of the surface type, it would be proportioned with sufficient surface to raise the feedwater temperature to within a reasonable terminal difference of the saturation temperature of the exhaust steam. This heater might be of the open type. However, the position in the system and the pumping arrangement would seem to dictate the choice of the closed heater. The feedwater would then flow through the tubes of the other section, where it would absorb the heat represented by the superheat in the exhaust steam. In reducing the temperature of the superheated exhaust steam, the temperature of the feedwater would be elevated above the saturation temperature of the heater. Steam of the desired temperature would be delivered to the low-pressure system, and the feedwater would be delivered to the boiler at a higher temperature than would be obtained from an ordinary saturation type feedwater heater alone.

By transferring the high-level heat, represented by the superheat in the exhaust steam, to the feedwater supplied to the boiler at a temperature above the saturation temperature of the heater, the use of exhaust heat in the cycle is increased, with a consequent increase in heat flow through the turbine and a greater electrical output.

The design of the thoroughfare-desuperheater section would be determined by the temperature desired for the steam supply for the low-pressure system, which would establish the terminal difference between the feedwater entering this section and the steam leaving it. It would be desirable to design the desuperheating section to maintain a somewhat lower temperature than that required by the system, in order to provide a range for automatic control of the temperature.

Fortunately, where saturated steam is required for process work, approximate saturation is generally acceptable and a small amount of superheat does not appear to be objectionable. This margin may be utilized to advantage in decreasing the size and cost of the

^{*} From a paper at the Semi-Annual Meeting of the American Society of Mechanical Engineers, San Francisco, July 10-15, 1939.

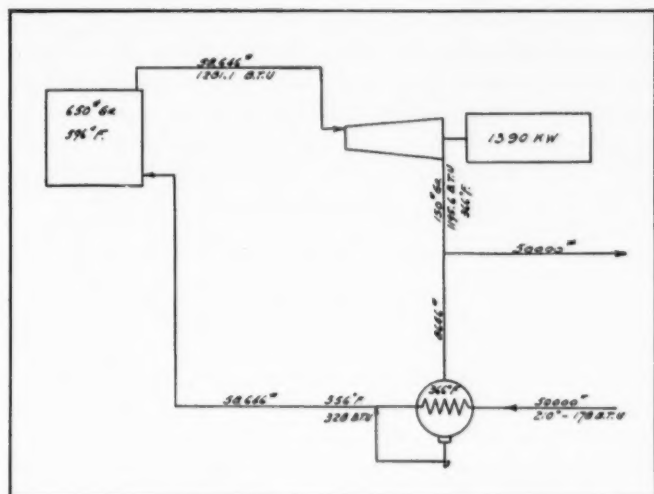


Fig. 1—Conventional application of non-condensing turbine supplying 50,000 lb per hr saturated steam at 150 lb gage pressure to process or other equipment

thoroughfare desuperheater by providing a higher terminal difference.

With certain choices of initial temperature and pressure, it is possible that, in absorbing the heat of the superheat in the exhaust, the feedwater to the boiler might attain too high a temperature to be conveniently handled. The temperature of the feedwater from the desuperheater can be regulated and held at the maximum allowable temperature by means of a bypass around the feedwater-heater section, with a temperature control.

The thoroughfare desuperheater and the feedwater heater might be built as two separate sections working together as a unit, or the two sections could be combined in a single shell, depending upon physical limitations or design characteristics. Between the heater section and the desuperheater section, provision should be made for detaining steam condensation from the thoroughfare section, to prevent its being carried into the low-pressure system.

Fig. 1 shows a conventional application of a non-condensing turbine supplying 50,000 lb per hr of saturated steam at 150 lb gage pressure to process or to other equip-

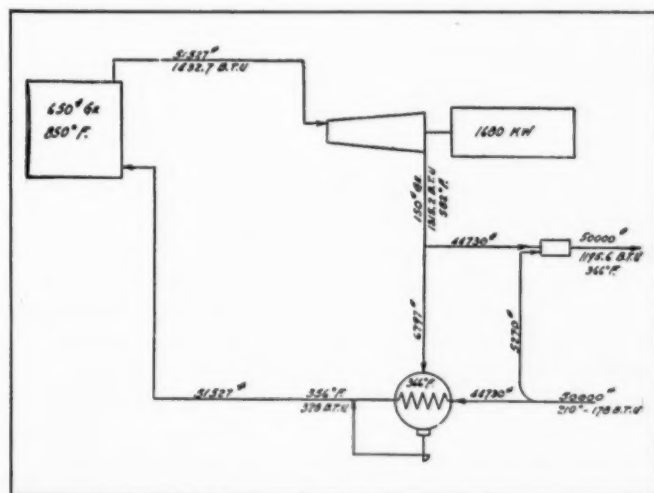


Fig. 2—Application supplying 50,000-lb saturated steam per hr at 150 lb gage pressure, using conventional desuperheater

ment. It is assumed that this 50,000 lb per hr is returned as feedwater at a temperature of 210 F from other feedwater heaters. A high-pressure feedwater heater is indicated, proportioned to heat the feedwater to a temperature of 456 F when supplied with 150 lb gage steam from the exhaust of the high-pressure turbine. With a pressure of 650 lb gage at the throttle and a turbine-generator efficiency of 64.6 per cent (turbine efficiency alone of 68.5 per cent), it is necessary to limit the total temperature at the throttle to 596 F in order to deliver saturated steam at the exhaust. This requires a steam flow of 58,646 lb per hr and gives an electrical output of 1390 kw. The heat supplied by the boiler for this combined steam-and-electrical load is 55,887,000 Btu per hr.

Fig. 2 shows an application to supply the same 50,000 lb of saturated steam per hr at 150 lb gage pressure, in

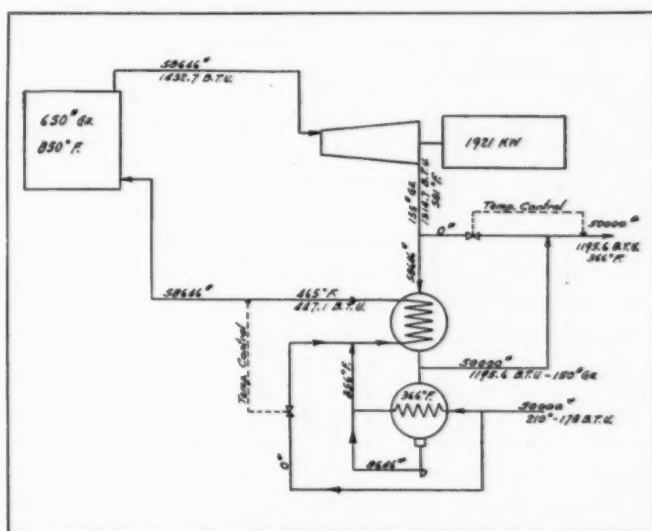


Fig. 3—Application of thoroughfare desuperheater and feedwater heater to supply 50,000 lb saturated steam per hr at 150 lb gage pressure

which 650 lb gage at the throttle is used with a total temperature of 850 F. With a turbine efficiency alone of 70.5 per cent, the exhaust steam from the turbine at 150 lb gage would have a total temperature of 582 F. With a conventional type of desuperheater as shown, when supplied with feedwater at a temperature of 210 F, a flow of 44,730 lb per hr of exhaust steam would be sufficient to furnish 50,000 lb per hr of saturated steam to the low-pressure system. This requirement, together with the necessary 150-lb steam to serve the conventional high-pressure heater to heat the feedwater to a temperature of 356 F, requires a flow at the throttle of 51,527 lb per hr, which produces an electrical output of 1680 kw. This increase of 290 kw is an increase of 20.9 per cent in the power output incident to the furnishing of the same quantity of low-pressure steam, as in Fig. 1, and is obtained from this application of the increase in initial steam temperature from 596 to 850 F. The heat supplied by the boiler for this combined steam-and-electrical load is 56,930,000 Btu per hr.

Fig. 3 illustrates the application of the thoroughfare desuperheater and feedwater heater to supply the same 50,000 lb of saturated steam per hr at 150 lb gage pres-

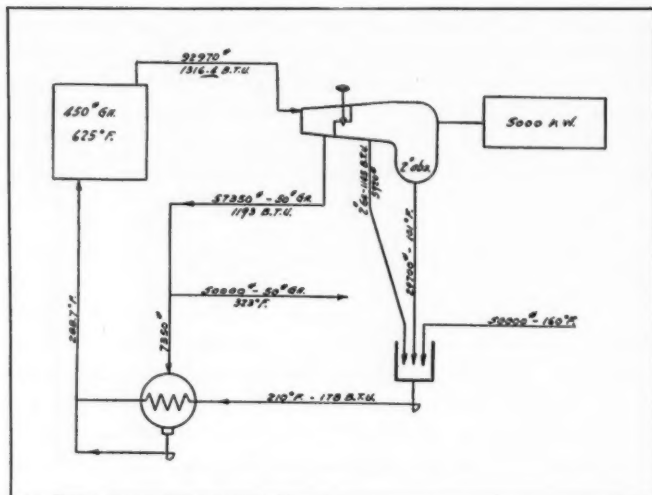


Fig. 4—Application of condensing-type extraction turbine to meet requirement of 5000 kw electrical output and low-pressure demand for 50,000 lb steam per hr at 50 lb gage pressure, 25 deg superheat

sure, with initial steam conditions as in Fig. 2; namely, 650 lb, 850 F at the throttle. To allow for a 5-lb pressure drop through the desuperheater, the back pressure at the turbine would be increased to 155 lb gage. With a turbine efficiency alone, of 72.8 per cent, the exhaust steam at 155 lb gage pressure will have a temperature of 581 F. The 50,000 lb of steam per hr, required by the process in passing through the thoroughfare-desuperheater section, is desuperheated by the feedwater and is supplied to the system at saturated temperature. Exhaust steam is absorbed in the feedwater-heater section in sufficient quantity to elevate the feed temperature from 210 to 356 F. The feedwater, in passing through the desuperheating section in contact with the thoroughfare flow of steam in counterflow direction, would be heated to a temperature of 465 F for return to the boiler, in absorbing the heat of superheat of the exhaust steam. The total flow required from the turbine is 58,646 lb per hr, which gives an electrical output of 1921 kw, a gain of 531 kw over Fig. 1, and a gain of 241 kw over Fig. 2, or 38.2 per cent and 14.3 per cent improvement, respectively. The heat supplied by the boiler for this combined steam-and-electrical load is 57,800,000 Btu per hr.

Figs. 1, 2 and 3 are presented to demonstrate the increase in power available in connection with supplying low-pressure steam and therefore are measured in terms of electrical output. The increase in boiler capacity to accomplish this gain is small, since it is but necessary to supply the heat represented by the added kilowatt output at the rate of approximately 3600 Btu per kw-hr. The relative amounts of heat supplied by the boiler, therefore, the relative boiler capacities required, compare as follows: Fig. 1, 100 per cent; Fig. 2, 101.8 per cent; Fig. 3, 103.4 per cent.

For installations where some superheat is desirable in the steam being furnished to the low-pressure system, the thoroughfare desuperheater might be designed with a greater terminal difference and equipped with a temperature control which would be arranged to control the proportion of exhaust steam routed through the desuperheater. Sufficient exhaust steam would be bypassed around the desuperheater so that, when mixed with the balance of the exhaust steam, the resultant mixture would

have the desired temperature. The bypass temperature control would be simple. It would consist of a damper or regulating type of valve which would be automatically positioned to proportion the flow through the desuperheater and around the desuperheater in a manner to give the necessary mixture to maintain the required temperature to the low-pressure system.

Application to Extraction Turbines

Similar gains and an improvement in thermal efficiency of the plant may be realized in the application of this scheme to condensing-type extraction turbines. The same proportional increase in output may be expected from the steam extracted for use in the process or the low-pressure system, which reduces the flow of steam to the condenser for a given output. In addition, the efficiency of the use of the condensed steam is improved, resulting in a gain from that portion of the flow commensurate with the gain on any condensing cycle by the increased inlet temperature.

Fig. 4 shows an application for an assumed requirement of 5000 kw electrical energy and a low-pressure demand for 50,000 lb of steam per hr at 50 lb gage, 25 deg superheat (323 F total temperature).

With 450-lb steam at the throttle, a total temperature of 625 F is required to give 25 deg superheat at the extraction opening at this load. With two stages of feedwater heating, the high-pressure heater served from the 50-lb extraction point to give a final feed temperature at the boiler of 288.7 F, and with 2 in. absolute back pressure at the condenser, a flow of 92,970 lb of steam per hr is required. The heat supplied by the boiler would be 98,455,000 Btu per hr.

Fig. 5 shows an application with load conditions similar to those shown in Fig. 4, except that a total temperature of 825 F is maintained at the throttle and a thoroughfare desuperheater is used to reduce the temperature of the 55 lb gage extracted steam to the desired 25 deg superheat. In this case the steam as extracted from the turbine would have a total temperature of 484 F (181 deg superheat). In reducing the temperature of this extracted steam in the thoroughfare desuperheater to the desired 25 deg superheat the feedwater would be heated to 336 F. The total flow of steam required from the

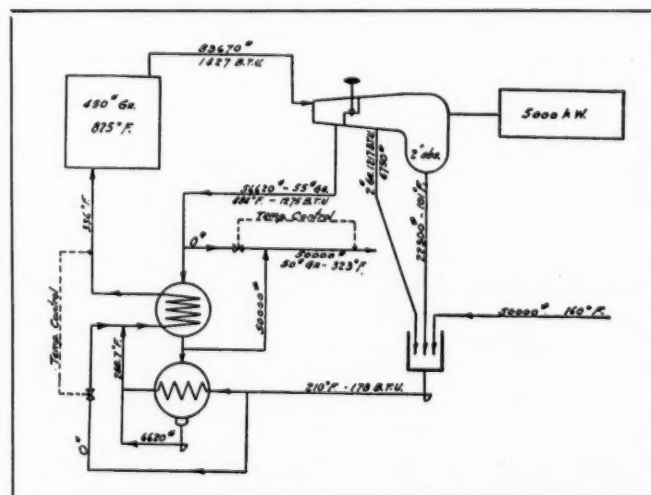


Fig. 5—Similar load conditions to Fig. 4, except that thoroughfare desuperheater is used

boiler would be 83,670 lb of steam per hr. The heat supplied by the boiler would be 93,710,000 Btu per hr.

As the steam-process load and the electrical load are held constant in the examples demonstrated in Figs. 4 and 5, the improvement in operation would be measured by decrease in fuel consumption. The saving of 4,745,000 Btu per hr in heat supplied by the boilers represents a reduction of 4.7 per cent in the fuel cost for supplying the steam-and-electrical load.

On non-condensing extraction turbines, the application of the thoroughfare desuperheater would be made at the extraction opening or at the exhaust, depending upon which low-pressure system served to limit the inlet-steam temperature. The results from the application would be in all respects similar to the non-condensing-turbine application.

No attempt has been made to determine the economic factors in the examples given. In evaluating the applications, consideration must be given to the costs due to the modified boiler flows, the added superheat, the increased turbine capacity required and the cost of the desuperheating equipment. As the resultant increased output from the non-condensing portion of the cycle is at a rate of approximately 3600 Btu per kw-hr, the allowable cost for the suggested application could be the same, per kilowatt of increased capacity, as is found to be justified for the so-called "topping" installations. The surrounding conditions are so diverse in applications of this nature that each case must be considered on its own merits. It is recognized that a thoroughfare desuperheater designed to a close terminal difference would be large. As previously pointed out, however, the operating margin usually will permit the use of a design that will serve to decrease the size.

Bituminous Coal Prices Announced

The National Bituminous Coal Commission has approved for publication minimum prices for coal produced in the various areas. These are prices at the mine and are subject to possible revision after a final hearing which has been set to begin on July 24 at Washington, D. C. Retail prices are not prescribed by the Commission.

Price Area No. 1, which produces about 70 per cent of the nation's bituminous coal output and includes the great Appalachian field, supplies the eastern consuming markets and also ships into the Great Lakes region, the north central, central, mid-western and some of the southern states. The mines are located in Pennsylvania, West Virginia, Ohio, Eastern Kentucky, Virginia, Tennessee, Maryland and Michigan. Within this area the quotations range from \$1.15 per ton for the lowest grade and smallest size of slack coals to \$3.35 per ton for the finest grade, largest size of lump. The average price is \$2.128 which is about two cents under the previous average price for this area.

While the prices for some smokeless slack coals from southern West Virginia have been increased about 20 cents per ton over prevailing quotations, those for steam sizes for the large eastern consuming areas show sub-

stantial reductions under the first prices established by the Commission. Prices for lump coals for the domestic market show reductions for winter delivery in the eastern markets. Following are some typical prices:

Best grade fine slacks from central Pennsylvania, for substantially all markets, \$2.15.

Beckley (W. Va.) slacks, for New England markets, \$1.76.

Ohio fine slacks, for Cleveland and Detroit markets, \$1.65.

Southern high-volatile slacks from southwestern West Virginia and western Kentucky, \$1.80 for the Harlan base 2-in. nut and slack for Detroit and Great Lakes.

Pittsburgh seam slacks from Fairmont, W. Va. field, \$1.65 for Cleveland markets.

Best grade Pittsburgh seam slacks from western Pennsylvania, \$1.90 for Cleveland and Buffalo markets.

Michigan slacks \$2.65 to \$3.

The law requires the prices to yield the producers in each district an average return per ton equal, as nearly as possible, to the determined average cost of production within the price area. The average cost of production for the several districts within Area No. 1, are: central Pennsylvania and part of Maryland, \$2.389; western Pennsylvania, \$2.214; northern West Virginia, \$1.837; Ohio, \$1.936; Michigan, \$3.654; West Virginia "Panhandle," \$1.978; southeastern West Virginia and part of Virginia, \$2.194; and southwestern West Virginia, eastern Kentucky, western Virginia and northeastern Tennessee, \$2.03.

Price Areas Nos. 2, 3, 4 and 5 include the central, southwestern and southern states. The prices established by the Commission for most of the coals produced in Arkansas, Missouri, Iowa and Alabama generally reflect present market levels, whereas those in other fields within these areas show general increases for industrial sizes but little change in the domestic sizes. Quotations for the lower grade industrial slack coals are substantially lower than those announced by the Commission in December 1937. Typical prices are as follows:

For Chicago market: southern Illinois industrial slack, \$1.70 per ton; southern Illinois 6-in. lump, \$2.65; central Illinois industrial slack, \$1.25; central Illinois lump, \$2.15; Indiana Fifth Vein industrial slack, \$1.45; Indiana Fifth Vein lump, \$2.15.

For St. Louis market: southern Illinois industrial slack, \$1.70; southern Illinois 6-in. lump, \$2.65; Belleville industrial slack, \$1.20; Belleville lump, \$2.25.

For Memphis market: western Kentucky industrial slack, \$1.20; western Kentucky large lump, \$2.25; western Kentucky "egg," \$1.95.

For Kansas City market: Kansas industrial slack, \$1.15; Kansas "fancy" lump, \$2.45; best grade Arkansas lump, \$3.85 to \$4.80.

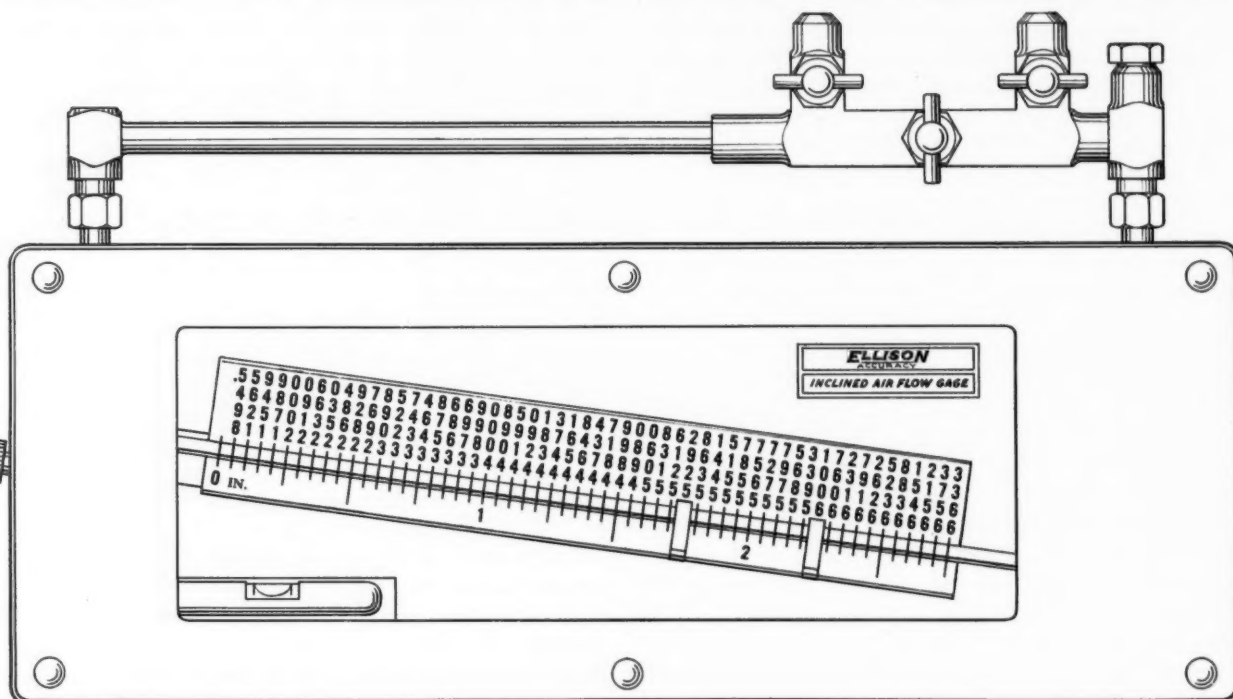
For Plains States markets: best grade Arkansas lump, \$3.85 to \$4.80.

For Birmingham market: Black Creek lump, \$4; White Ash lump, \$2.50; best grade Black Creek washed steam coal, \$2.70; best grade Big Seam washed steam coal, \$2.15 (all coals quoted here are produced in Alabama).

For Des Moines market: standard lump, \$3.43 for coal from mines shipping on a 62½-cent freight rate; industrial slack, \$1.98 for coal from mines shipping on a 56½-cent freight rate (all coals quoted here are produced in Iowa).

The Commission has previously published schedules and conducted hearings on prices for the Rocky Mountain and the Pacific Coast Areas, although these have not yet been made effective.

The individual prices for the different coals vary to reflect relative values as to kind, quality, size and other factors. Due regard was given to such elements as the preservation of existing fair competitive situations between producers and producing districts, and to the interests of the consuming public.



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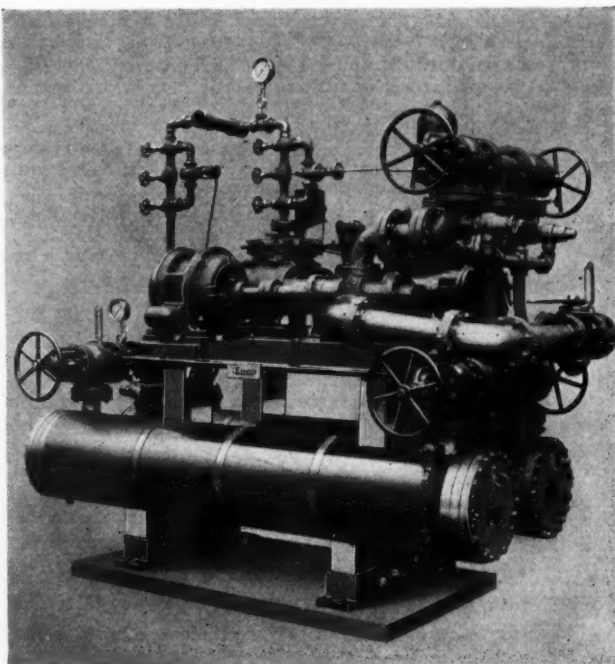
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BRIMSDOWN—England's First 2000-Lb Installation

At the Brimsdown Station of the North Metropolitan Power Supply Company there have been in operation since the end of last year two 210,000-lb per hr Loeffler boilers supplying steam at 1900 lb per sq in. and 940 F, at the turbine throttle, to a 19,000-kw high-pressure turbine-generator exhausting at 160 lb to a 34,000-kw low-pressure unit. The following notes, describing certain features of the boilers, are based on information contained in the current issues of several British technical magazines¹ to which descriptions were simultaneously released.

AT Brimsdown there are two stations—"A" which is a stoker-fired plant operating at 160 lb pressure, and "B" a pulverized-coal-fired plant completed in 1929 and operating at 350 lb pressure. The boilers of the present high-pressure extension, which are stoker-fired, are located in a new building, although the turbine generators are accommodated in the turbine room of Station "A." Two additional Loeffler boilers of slightly

¹Engineering and Boiler House Review, Industrial Power and Fuel Economist, The Power and Works Engineer and Engineering.

greater capacity, namely, 250,000 lb per hr each, are now under construction and will supply 60,000 kw of new turbine-generator capacity to be located in Station "B."

To date the best weekly performance of the new installation has been an overall thermal efficiency of 29.25 per cent, although it is expected shortly to attain the 30 per cent for which it was designed.

In the Loeffler boiler, it will be recalled, steam is generated in an evaporator drum (not exposed to the hot gases) by means of superheated steam that is circulated by a pump through the tubes of a radiant superheater surrounding the combustion chamber. This steam then passes to a convection superheater, at the outlet of which it divides, one-third going to the turbine and two-thirds being returned to the evaporator drum where it is discharged through nozzles below the water line and evaporates the feedwater. The diagram, Fig. 2, will serve to make this clear. For starting, an external supply of low-pressure steam is required. In the Brimsdown units the steam circulating pump is required to operate against only 70-lb head which represents the friction of the steam path.

Each of the present boilers is rated at 210,000 lb per hr and generates steam at 2000 lb per sq in. and 940 F total temperature. This steam from the two units is delivered to the throttle of the 19,000-kw high-pressure turbine at 1900 lb and after passing through the turbine

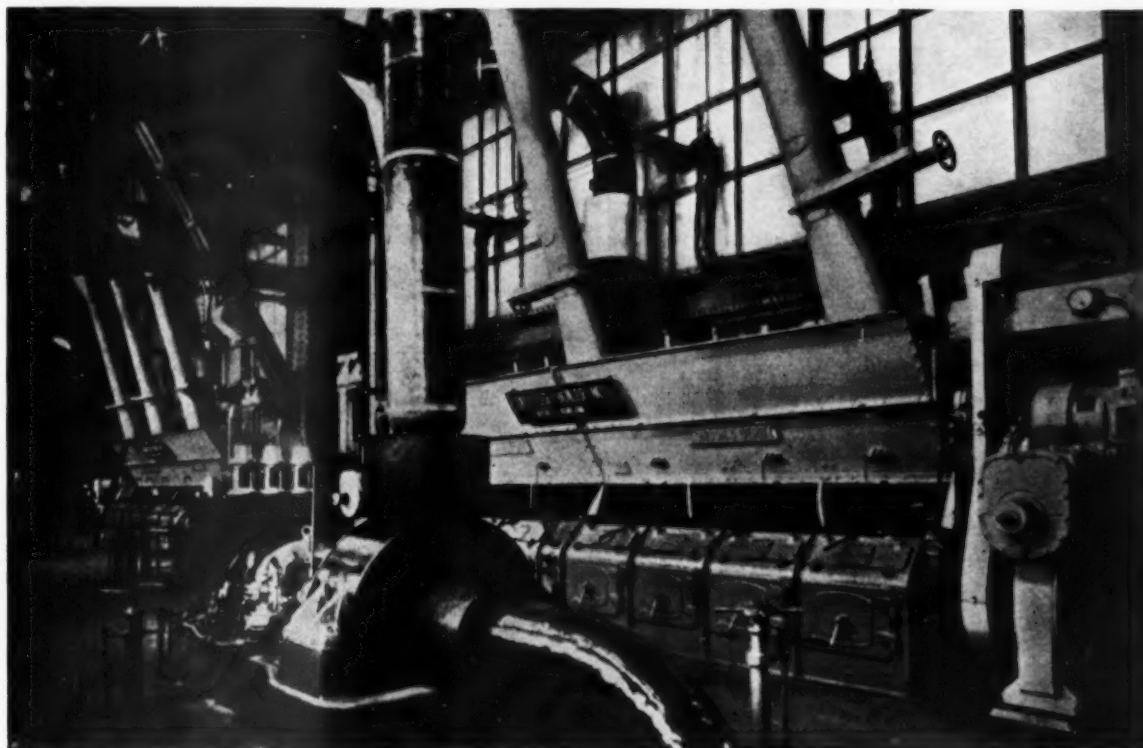


Fig. 1—Boiler fronts at firing floor, showing steam-circulating pump in foreground

is reheated to 810 F, by reheaters incorporated in the boilers, and led to the 34,000-kw low-pressure condensing turbine at 160 lb. Inasmuch as this corresponds with the pressure of the old units in Station "A" it is possible to run the low-pressure turbine on steam from the old boilers, should the high-pressure turbine be out of service. The high- and low-pressure turbines normally operate as a single unit, the governor gear of the low-pressure machine being arranged to come into action only if the speed of the set exceeds a predetermined value.

Boiler Details

Each boiler is provided with three evaporator drums removed from contact with the hot gases by being located in the basement, outside the setting (see Fig. 4). These are cylindrical forgings 27 ft 4 in. long, 3 ft 7 in. inside diameter and with walls $3\frac{1}{4}$ in. thick. At the ends, plates 12 in. thick are screwed and shrunk on, over which there are external shrink rings. All connections are taken off these end plates. The drums are of 72,000–80,000 lb Siemens acid open-hearth steel. Access to the interior of the drums is through manholes in the end plates. The saturated steam from these drums passes to the steam circulating pump which discharges to the front wall header of the boiler.

The heating surface surrounding each furnace consists of a radiant superheater of 2300 sq ft, whose chrome-molybdenum steel tubes are placed some 9 in. in front of the refractory walls. At the outlet of the radiant superheater the steam temperature is 780 F. After leaving the furnace the products of combustion pass over an 8600-sq ft convection superheater, thence over a steam reheater to the economizer and Howden-Ljungström air preheaters of which there are two per boiler.

Both gas and steam-to-steam reheaters were provided in the design, but it has been found unnecessary to use

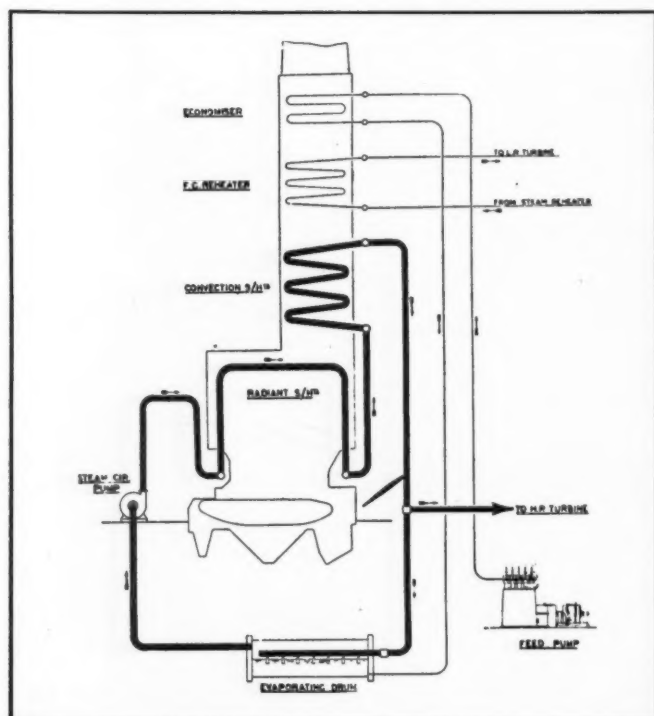


Fig. 2—Diagram of Loeffler circuit

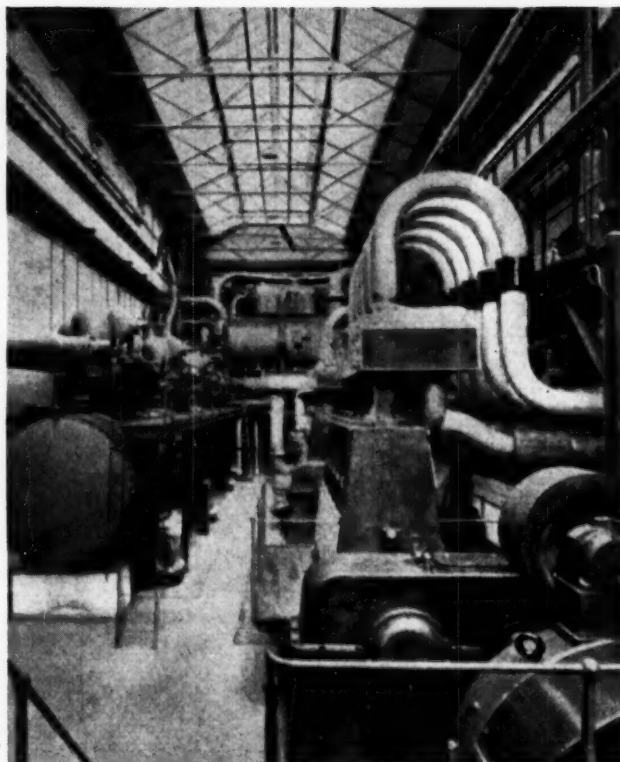


Fig. 3—Reciprocating feed pumps on right; evaporators on the left

the latter, hence they will not be incorporated in the layout for the second pair of boilers.

The heating surfaces and the external superheated steam piping are of chrome-molybdenum steel containing 0.8 per cent chromium and 0.5 per cent molybdenum. Long-time creep tests at 950 F and 1000 F, as well as mechanical tests, were carried out at the National Physical Laboratory on samples of the material to make sure that it was suitable before being approved.

Plain carbon steel is used for the feedwater piping and for the saturated steam piping.

Welding Procedure

Welded construction is employed throughout. The ends of tubes to be welded were first sized to their internal diameters and the ends chamfered to an angle of $37\frac{1}{2}$ deg to the vertical so that a V of 75 deg was formed for welding. This chamfer was not carried through the full thickness of the tube but terminated $\frac{1}{32}$ to $\frac{3}{32}$ in. from the bore, depending upon the thickness of the bore. No external sleeves were used. After welding, each joint was normalized by being heated to 1600–1700 F by means of a gas flame and allowed to cool slowly. The majority of the welds in the boilers, headers and piping, together with some of the heating surface, were X-rayed to make sure they were up to the requirements. Flanged joints were used only where necessary for dismantling purposes.

For connecting the tubes to the headers, small nipples were first formed on the headers, to which were welded short lengths of tubing about 9 in. long and the whole assembly heat treated. The nipples were pushed out of the headers by means of an hydraulic jack fitting in the bore of the header and with the head of the ram shaped to the required contour.

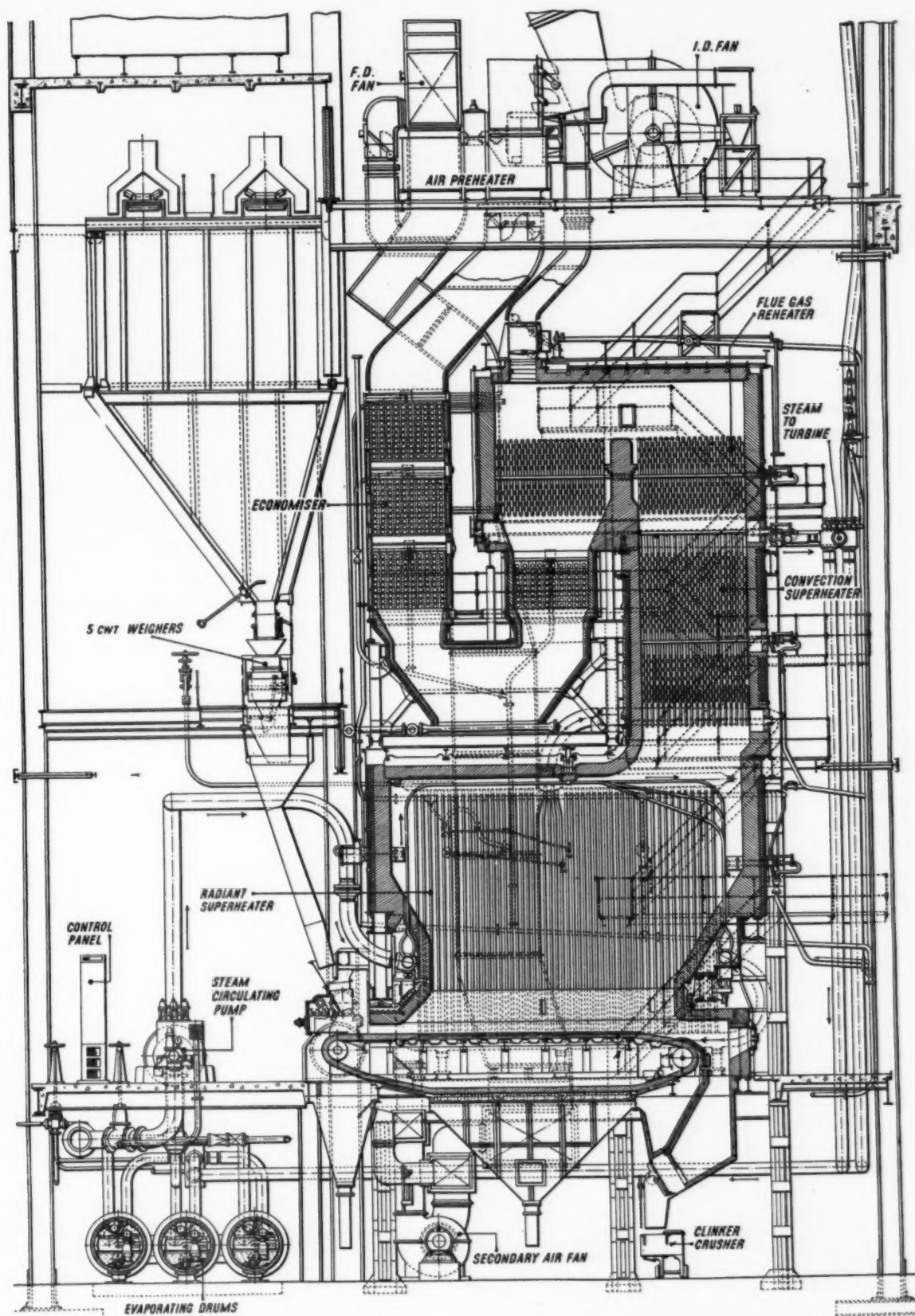


Fig. 4—Cross-section through boiler; note location of evaporating drums

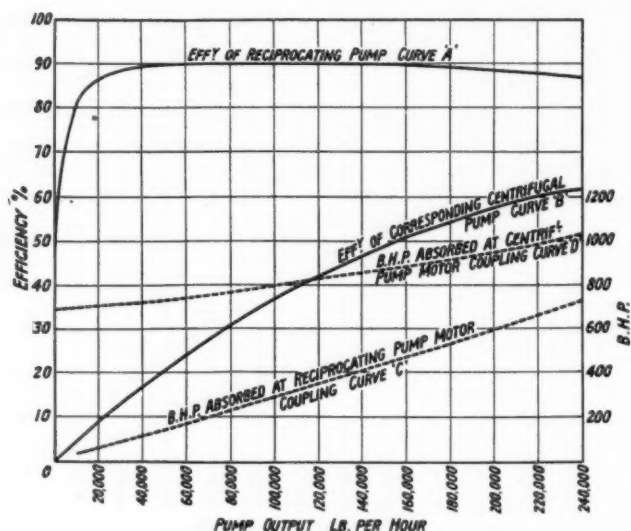


Fig. 5—Comparative performances of reciprocating and centrifugal pumps for high-pressure feed service

Magnetic-type water level indicators are provided, two to each boiler and each is connected to a different evaporator drum. However, for checking purposes gage glasses, suitable for withstanding the full pressure, are installed.

Feed and Circulating Pumps

Feedwater is handled in two stages, there being duplicate centrifugal lift pumps which supply the suction of the main reciprocating boiler feed pumps (one per boiler) through high-pressure bleed-steam heaters. The lift pumps are motor driven and deliver the feedwater at 227 F against 325 lb pressure. A turbine-driven lift pump serves as standby.

Taking the feedwater at this pressure, the reciprocating feed pumps, each driven through reduction gears by an 800-hp motor, deliver the feedwater to the economizers. These pumps are five-throw units with $5\frac{1}{2}$ -in. pistons and 12-in. stroke, running at 100 rpm.

The curves of Fig. 5 show that higher efficiency, for the given conditions, is attainable with such reciprocating pumps than from pumps of the centrifugal type throughout almost the whole range of duty. On test the efficiency of these pumps, together with the driving gears, was 89 per cent at full load, or 3 per cent higher than anticipated. Another reason for their adoption was that, whereas the discharge pressure of a centrifugal pump of suitable characteristics is some 10 per cent higher at no load than at full load, a reciprocating pump does not exceed the pressure required to feed into the boiler; hence the discharge pressure with a reciprocating pump decreases with the load owing to the lower frictional loss in the discharge piping. Also the reciprocating units lend themselves more readily to variable voltage speed control.

For standby service there is a turbine-driven centrifugal pump of the same capacity as one of the reciprocating units, namely 240,000 lb per hr. This pump has a solid forged barrel, nine stages and gives its rated discharge at 380 F from a suction pressure of 300 lb per sq in. against 2300 lb when running at 4000 rpm.

The steam circulating pump for each unit is located on the firing floor immediately in front of the boiler.

They are of the centrifugal type and turbine-driven, because of the considerable range in speed required. These turbines take their steam from the high-pressure turbine exhaust. At this point the pressure and temperature of the steam fluctuate in accordance with the load on the main unit and the pump turbines were designed to meet this condition. However, when the steam pressure falls below 85 lb, due to light load on the main unit, a reducing valve in an auxiliary line from the radiant superheat outlet opens so as to maintain the desired pressure in the auxiliary steam supply receiver. Steam exhausted from these turbines discharges to the deaerating heater and the evaporating plant. The pump casings are special steel castings and the stainless steel impellers are carried on shafts which are sealed by long glands containing carbon rings.

The pressure difference across the circulating pumps is approximately 70 lb per sq in.; hence they are of single-stage design.

Stokers and Control

Each boiler is fired by a twin "L" type chain-grate stoker 25 ft wide by 23 ft long, and having a grate area of 575 sq ft. Overfire air is provided by 22 secondary air nozzles arranged along the front wall of the boiler. This large number was adopted so that alternate nozzles could be cut out at light loads.

A Ward-Leonard system of control is installed. This is arranged in such a manner that the auxiliaries associated with one boiler can be controlled as a group; and by means of a master controller both boilers can be operated as a unit if desired.

A.S.M.E. Nominations

Nominations for officers of The American Society of Mechanical Engineers for 1940 were announced at a recent meeting of the regular nominating committee held at State College, Pa. Election will be held by letter ballot of the entire membership, closing on September 26, 1939. The nominees as presented by the committee of the Society are:

President—Warren H. McBryde, Consulting Engineer, San Francisco, Calif.

Vice-Presidents—Kenneth H. Condit, Ex. Asst. to President of The National Industrial Conference Board, New York, N. Y.

Francis Hodgkinson, Consulting Engineer, New York, N. Y.

J. C. Hunsaker, Head of Dept. of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Mass.

K. M. Irwin, Asst. to V. P. in Charge of Engineering, Philadelphia Electric Co., Philadelphia, Pa.

Managers—J. W. Eshelman, President, Eshelman & Potter, Birmingham, Ala.

Linn Helander, Head of Mechanical Engineering Department, Kansas State College, Manhattan, Kansas.

Guy T. Shoemaker, President, The United Light & Power Service Co., Chicago, Ill.

Application of the Glass Electrode to pH Determinations

By R. T. HANLON

Chemist, Technical Service Department
Consolidated Edison Co. of N. Y., Inc.

During the past decade, the use of the glass electrode for pH determination of power plant waters has become widespread. It has been possible by the use of this electrode to extend the use of the pH scale to the measurement of unbuffered waters, such as condensed steam and turbine condensate, and as a result to make determinations of acidity and alkalinity which could not be accomplished by using ordinary analytical methods.

WITH the recent development of high-pressure steam generating equipment, the significance of small changes in the acidity or alkalinity of boiler feedwater, condensed boiler steam and turbine condensate has become increasingly important. It is therefore essential that the greatest possible accuracy be obtained in this measurement in order that data of sufficient reliability be available to adjust correctly these values in the water or steam and as a result improve the overall operation of the boiler.

The hydrogen electrode is the primary standard for the measurement of hydrogen ion concentration. This employs a platinum black electrode in conjunction with a half cell of saturated calomel which is saturated with potassium chloride and a salt bridge of saturated potassium chloride. The solution upon which the determination is to be made is placed in a suitable vessel and the platinum black electrode and the calomel half cell are immersed in the solution. A current of purified hydrogen is bubbled past the electrode and through the solution. When equilibrium is reached a potential is read across the entire cell. This potential is a measurement of the solution's pH value. When this electrode is used, the relationship between the potential generated across the cell and the pH value is linear; that is, at a given temperature an identical change in potential will occur with an equal change in hydrogen ion concentration.

It is unfortunate that this electrode is not applicable to the pH determination of unbuffered solutions. This is because the passage of the hydrogen through the solution results in the removal of some of the more volatile materials in the water, as carbon dioxide and ammonia. The presence of these gases in solution, particularly when the solution is unbuffered, has a marked effect upon its pH value. It is therefore desirable to measure the effect of all the ions in the solution including those

of these dissolved gases. In that these gases are partially removed when the hydrogen electrode is used, any data obtained when the solution upon which the determination is being made is unbuffered are of doubtful value.

The use of colorimetry to determine the pH value of power plant waters has yielded fairly accurate results

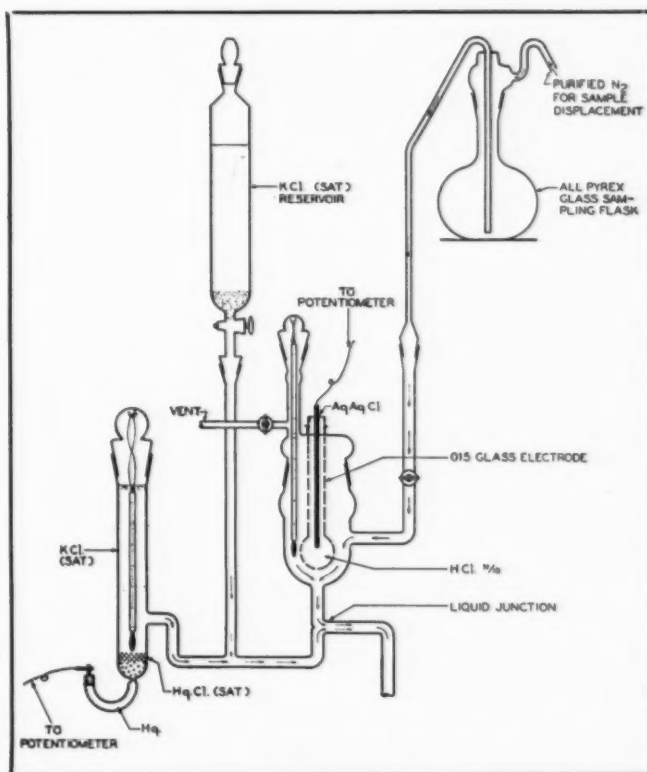


Fig. 1—Arrangement of glass electrode in Pyrex glass-flow cell

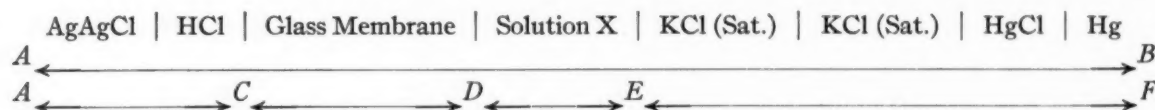
when an isohydric or semi-isohydric technique is used and when the solution upon which the determination is being made is at least partially buffered. It is possible to maintain an overall accuracy of plus or minus 0.2 pH under these conditions. The use of the colorimetric method, however, limits the pH determination of power plant waters to that of feedwater and of boiler water. It is not possible under any conditions to make accurate colorimetric pH determinations upon the unbuffered power plant solutions such as condensed steam and turbine condensate.

The glass pH electrode combines the accuracy of the hydrogen electrode with the rapidity of operation of the colorimetric method. It is superior to the hydrogen electrode in its application to the pH determination of

power plant waters in that it is possible to make pH determinations upon unbuffered solutions. This is possible because it is unnecessary to pass any gas through the solution upon which the determination is being made. Hence, as none of the ions in the solution are removed, the pH value of the solution is maintained as it was when the solution was placed in contact with the electrode. Its superiority over the colorimetric method lies in the electrode's ability to measure the pH value of plant

removes from it the "history" of the previous sample. The solution is permitted to flow through the cell at a rate which results in a slow drip at the cell discharge. Care should be taken to avoid grounding the sample at this discharge by causing the sample to be ejected in a steady stream. If this occurs any readings taken will be of no value.

The pH cell assembly shown in Fig. 1 employs the following chain:



solutions regardless of the unbuffered characteristic of the solution.

It is possible by the use of this electrode to make determinations of pH value over the range between 2.0 and 11.4 pH if a proper standard buffer solution calibration is made, and if precautions are taken to protect the samples from atmospheric contamination. The effect of the solubility of the glass of which the electrode is composed must also be taken into consideration and the electrode vessel so designed that this effect can be avoided.

Sampling Procedure

Proper sampling of the plant water is also an important factor in the accurate determination of its pH value. The sampling of the solution is particularly important in the case of the more unbuffered waters such as condensed boiler steam and turbine condensate. This can be accomplished simply by the employment of a condensing coil constructed of some non-corrosive material such as stainless steel or block tin. All valves in the steam and water lines should be tight. The sampling tube should be inserted in a long straight length of the header or pipe and should not be placed adjacent to bends or pockets where the circulation of the solution may be impaired. The sample should be taken in an all Pyrex glass sampling flask. If the samples as taken are hot and must be cooled before determination is made, the cooling should be done under an atmosphere of purified nitrogen.

Fig. 1 shows a typical arrangement of a glass pH electrode enclosed in a flow cell. This cell employs saturated calomel and silver-silver chloride half cells as reference electrodes. It will be noted that the cell also employs a flow-type liquid junction of saturated potassium chloride. It is essential that this type of junction be employed where the electrode is used to measure the pH values of solutions which are characterized by wide variation in pH value as are power plant solutions. In this manner contamination of the more unbuffered solutions is avoided. If the combined calomel reference and ground glass type of junction is used contamination of the unbuffered plant solutions is almost inevitable. A further reference to Fig. 1 will disclose that the sample is displaced by purified nitrogen. Contamination of the sample by the atmosphere is thus avoided.

The capacity of the useful portion of the cell vessel is approximately 40 cc. The vessel is so designed that the incoming sample completely washes the electrode and

where $A-B$ is the total potential across the entire cell (V_T)

$A-C$ is the potential of the silver-silver chloride half cell (V_S)

$C-D$ is the asymmetry potential of the glass electrode (V_A)

$D-E$ is the generated potential due to the hydrogen ion concentration of solution X (V_X)

$E-F$ is the potential of the calomel half cell (V_C)

In that the value of V_X varies with hydrogen ion concentration, being in the order of 0.06 volt per pH, it is necessary to evaluate the change in V_X if we are to measure the pH value of the solution.

It is therefore necessary to determine the values of all other voltages other than V_X and subtract them from the total cell voltage (V_T). Thus

$$V_X = V_T - V_S - V_A - V_C$$

Some of these potentials are positive while others are negative; that is, the values of V_T and V_C are plus voltages while those of V_S and V_A are minus voltages. Hence the actual equation for the determination of the value of V_X is

$$V_X = V_T + V_S + V_A - V_C$$

The potential of the silver-silver chloride electrode varies between -0.351 and -0.353 volt in the temperature range between 21 and 30 C.

The potential of the calomel half cell has a variation between $+0.248$ and $+0.242$ volt in the same temperature range. If the temperatures of the AgAgCl half cell and the calomel half cell are maintained between 21 and 30 C their algebraic sum may be combined as -0.106 volt and applied to the equation thus

$$V_X = V_T + (V_S - V_C) + V_A$$

or

$$V_X = V_T + 0.106 + V_A$$

The asymmetry potential (V_A) is the voltage across the glass membrane which in a thin glass electrode varies between 0.002 and 0.005 volt. In some of the recently developed thick glass electrodes, however, this potential may reach a value as high as 0.02 volt.

The potential of the silver-silver chloride half cell may be varied by adjusting the concentration of the hydrochloric acid within the glass electrode in contact with the silver-silver chloride reference. An adjustment of this acid may be made which will have the effect of decreasing the apparent value of V_A .

It is desirable to maintain the total value of V_A , which in this electrode reflects any variation from the theoretical potential of the AgAgCl reference, as low as possible. If it is desired to decrease the apparent value of V_A , a few drops of 0.2 mol hydrochloric acid is added to the 0.1 mol HCl solution within the electrode. If, however, the asymmetry potential is a minus number, as used in the final equation the acid within the electrode is diluted with distilled water.

Adjusting Electrode Potential

The following procedure is recommended to adjust the asymmetry potential of the electrode.

Select a standardized buffer solution in the order of 8.0 pH. Place the solution in the pH cell. Then add either hydrochloric acid or distilled water as necessary, taking precaution to agitate thoroughly the solution within the electrode as the adjustment is made.

The following procedure is used to determine the value of V_A

1. Determine the theoretical hydrogen voltage (V_H). This is accomplished by obtaining the product of the pH value of the buffer solution used and the concentration cell factor A (see Table)¹
2. The calculation is then made.

$$V_H - V_T + 0.106 = V_A$$

This procedure is repeated until the value of V_A is between +0.002 and +0.005 volt, as applied in the final equation.

VARIATION OF POTENTIALS OF SILVER-SILVER CHLORIDE AND CALOMEL HALF CELLS AND CONCENTRATION CELL FACTOR IN TEMPERATURE RANGE BETWEEN 21 AND 30 C

TEMPERATURE DEG C	VOLTS		
	AgAgCl Half Cell Potential (Vg)	HgHgCl Half Cell Potential (Vc)	Conc. Cell Factor Potential Volts (A)
21	0.353	0.248	0.0583
22	0.353	0.248	0.0585
23	0.353	0.247	0.0587
24	0.353	0.246	0.0589
25	0.352	0.246	0.0591
26	0.352	0.245	0.0593
27	0.352	0.244	0.0595
28	0.352	0.244	0.0597
29	0.352	0.243	0.0599
30	0.351	0.242	0.0601

A buffer solution calibration is then made over the range between 6.0 and 11.6 pH at intervals of 1.0 pH. When this is done, it will be observed that the value of V_A is constant up to approximately 10.0 pH. Above this value the V_A appears to increase and continues to increase with hydroxyl ion concentration. This variation from the linear potential—pH relationship of the glass pH electrode (Fig. 2) is caused by the presence of relatively high concentrations of the Na^+ ion in the solution in contact with the electrode. The error is therefore known as the sodium error and is so identified by the symbol V_{Na} .

Therefore the calculation for determination of pH value below 10.0 pH is:

$$\text{pH} = \frac{V_T + 0.106 + V_A}{A}$$

while above 10.0 pH it is necessary to include the cor-

¹ The Determination of Hydrogen Ions, 3rd Edition, 1928, Clark.

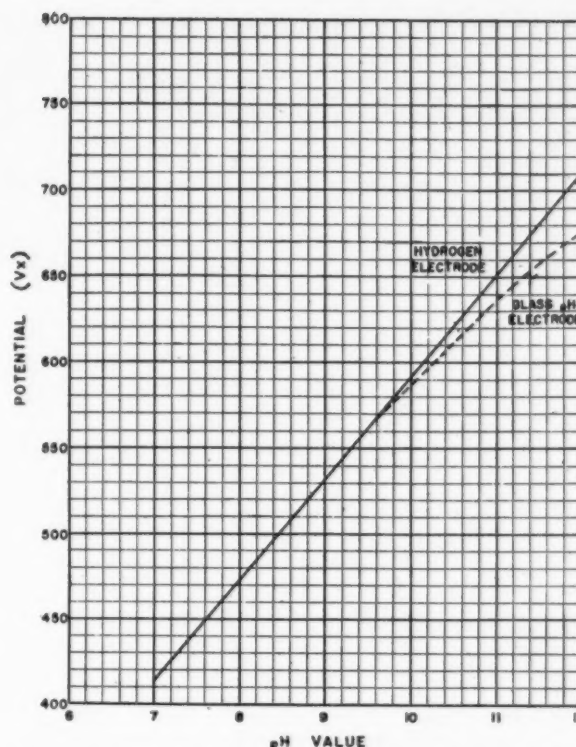


Fig. 2—Comparison of voltages of glass pH electrode and hydrogen electrode

rection for the sodium error; thus,

$$\text{pH} = \frac{V_T + 0.106 + V_A + V_{Na}}{A}$$

A graph may be simply constructed which will include the correction for V_A and V_{Na} and will correct for the variation in the concentration cell factor A with temperature between 21 and 30 C.

A glass pH electrode calibrated according to this procedure will yield an overall accuracy of ± 0.1 pH over the range between 2.0 and 11.4 pH.

Arnold E. Weichert, for the past 24 years with Combustion Engineering Company, Inc., in engineering, estimating and sales work, died suddenly of coronary thrombosis on July 2 at his home in Bloomfield, N. J. Mr. Weichert was born in Staten Island, N. Y., December 24, 1875, and received his early education in the New York public schools and in Germany. After spending two years at City College, he entered Stevens Institute of Technology and graduated with the degree of M.E. in 1897. He had been a member of the A.S.M.E. since 1907.

Bert Houghton, retired operating superintendent of the Brooklyn Edison Company, died on June 17 after an illness of several months. Born in Pittsfield, Vt., in 1867 and graduated from Cornell University in 1892, Mr. Houghton became associated with E. D. Leavitt, consulting engineer, later entering the motor department of General Electric Company. In 1896 he became associated with Lockwood Green & Co., and later entered the employ of the Boston Edison Company where he was engaged in station design and operation. He joined the Brooklyn Edison Company in 1912.

STEAM ENGINEERING ABROAD

As reported in the foreign technical press

Underground Power Station

The accompanying illustration, reproduced from *The Brown Boveri Review* of April-May 1939, shows a bomb-proof power station that has been installed in a tunnel in a mountain. For very obvious reasons, it is not identified.

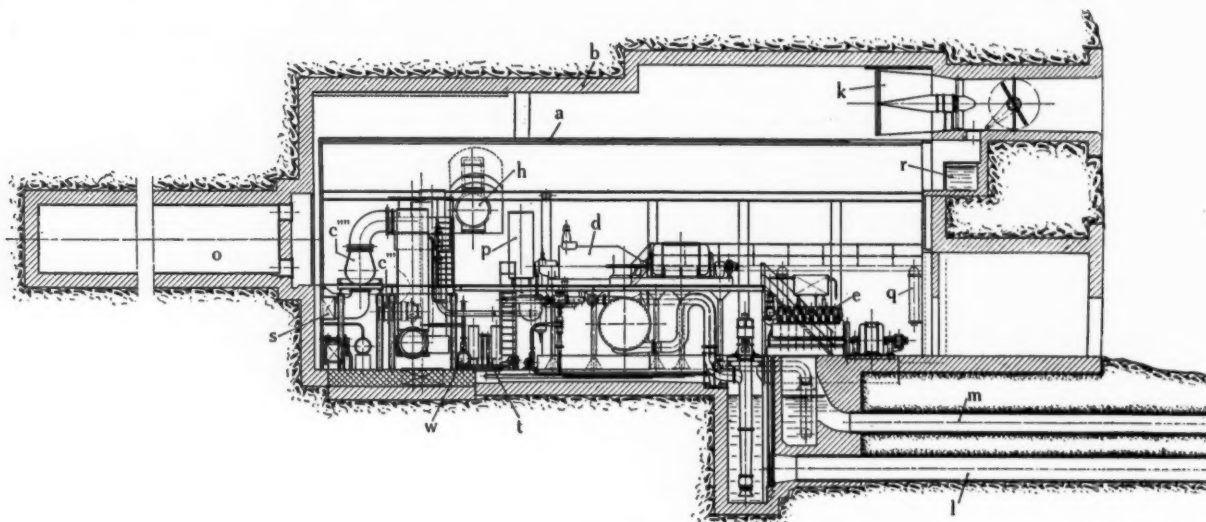
The plant is rated at 9000 kw and consists of an oil-fired Velox boiler of about 90,000 lb per hr capacity supplying steam at 340 lb pressure 780 F, to a single-cylinder condensing turbine-generator. An auxiliary diesel set is installed for starting up the plant independently of an external supply of electricity.

For structural reasons the room has been made in the form of a horizontal tunnel of about the dimensions of

Burning Pitch in Pulverized Form

E. B. Davies, in a recent paper before the Institute of Fuel (British), discusses the burning of pitch under boilers, both in the hot liquid state and in pulverized form. As a liquid it has long been burned with steam atomization under Lancashire boilers at the works where pitch is a by-product; but the problem of delivering hot pitch in lagged tanks or remelting it after solidification, has restricted its burning in liquid form.

In some cases, however, the pitch is allowed to solidify and is delivered to consumers in hard lump form. These lumps are then crushed and pulverized and the pitch burned in a similar manner to that of pulverized coal. The author cautions that certain types of mills, such as



9000-kw Velox steam power station built into a tunnel

- | | |
|---|--|
| a. Structure. | k. Fan. |
| b. Excavation of tunnel. | l. Cooling-water intake channel. |
| c. Velox boiler with steam separator (c'). | m. Overflow and outlet channel. |
| Exhaust-gas heated economizer (c''). | n. Pipe for exhaust gases. |
| Circulation pump (c'''). | o. Main fuel tank. |
| Charging set (c'''). | p. Auxiliary fuel tank. |
| d. Turbo-set with generator and condensing plant. | q. Tank for diesel-engine fuel. |
| e. Diesel-set for starting up. | r. Cooling-water tank for diesel engine. |
| f. Switchgear. | s. Combustion air for Velox boiler. |
| g. Ward-Leonard control for Velox boiler. | t. Preheater for fuel and filtering equipment. |
| h. Feedwater tank. | w. Feed water pump. |

a double railway tunnel and, in order to exclude moisture, the useful space is separated from the outer masonry lining of the shaft by means of an inner lining. Access to the outside is through a small shaft. The useful floor area is under 2500 sq ft and the volume 5 cu ft per kilowatt.

The plant has been built not far from a river in order to have sufficient condensing water available.

The same article describes two other power stations of similar construction which have lately been completed. One of these is arranged for automatic starting.

the ball, tube and edge-runner types, are unsuited to pulverizing pitch because of its tendency to become adhesive due to the heat produced by grinding. Once adhesion begins the building-up process accelerates rapidly. The high-speed air-swept hammer-type of mill has been found to give excellent results with pitch. A nine-hour test on two low-pressure Lancashire boilers burning pitch pulverized by such a mill gave the following results:

Heating value of pitch	16,000 Btu per lb
Pitch consumed	14,410 lb

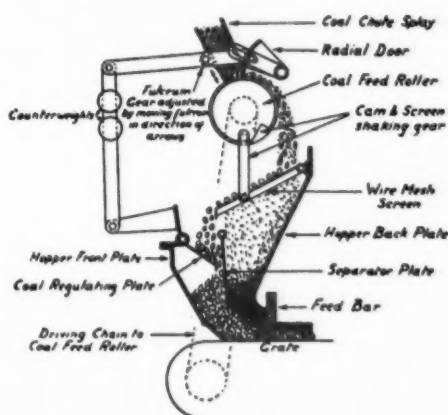
Water evaporated	16,422 gal
Steam pressure	83 lb per sq in.
Flue gases CO ₂	15-18 per cent
O ₂	1-14 per cent
CO	None
Stack temperature (at base)	280 F
Thermal efficiency	81.5 per cent

Italian Motor Plant Employs High Pressure

At the new Fiat Works, Mirafiori, Italy, high-pressure steam at 1565 lb pressure and 840 F is being generated by three 220,000-lb per hr boilers. This steam supplies back-pressure turbines which exhaust at approximately 150 lb to heat exchangers and the condensate is returned to the feed tank. All makeup is evaporated. The steam from the heat exchangers, or evaporators, is used in steam hammers which, in turn, exhaust to a steam storage system that supplies a 4450-kw low-pressure turbine-generator and also operates in conjunction with the hot-water heating system. A description of the installation is contained in *Die Wärme* of April 8, 1939.

Burning Pea and Duff in Layers on Chain Grates

The Power and Works Engineer for June contains an abstract of a paper by Messrs. Pickles and Redman in the *Journal* of the South African Institute of Engineers relating experiences in burning low-grade coal on chain-grate stokers at the Vereeniging power plant of the Victoria Falls and Transvaal Power Company. The adoption of high flat ignition arches enabled coal of 7625 Btu per lb heating value and 32.5 per cent ash to be burned, but difficulty was experienced from segregation of the pea size and duff, which resulted in uneven fires, delayed ignition and loss of capacity. To over-



Device for segregating and feeding pea and duff to chain-grate stoker

come this the authors developed the idea of deliberately segregating these sizes and feeding the pea coal next to the grate with the duff on top.

The accompanying sketch shows the means finally employed to effect the segregation automatically, control the rate of feed from the chute to the screen and shake the latter intermittently to dislodge sticky material. Its operation is self-explanatory.

COMBUSTION—July 1939

POSITIVE Protection

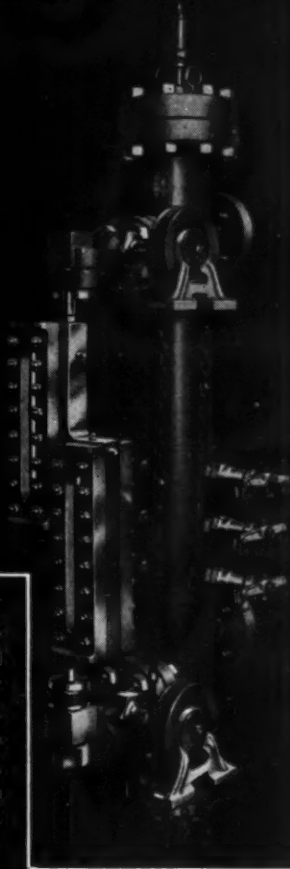


Fig. No. 4114: Yarway Forged Steel Water Column for 900 lbs. pressure. Equipped with Yarway Vertical Gage, Fig. No. 4178, with four-glass steel insert.

Hundreds of leading utilities and industrial plants insist upon Yarway Water Columns to protect their boilers.

Yarway's unique Hi-Lo Alarm mechanism utilizes balanced *solid weights* that are as indestructible and unchanging as the metal itself. Operating on the displacement principle, they literally "weigh the water level."

When the high or low water emergency occurs—instant, positive, powerful, hair-trigger action results—giving warning of danger by whistle, light, or both.

Yarway Water Columns, eight standard models, iron bodies with screwed connections for pressures up to 250 lbs., forged steel bodies with flanged connections for pressures up to 1500 lbs., are fully described in Catalog WG-1806. Write for a copy and working model.

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Philadelphia

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FLOATLESS HI-LO ALARM
WATER COLUMN

NEW CATALOGS AND BULLETINS

Any of these publications will be sent on request.

Nickel and Nickel-Base Alloys

This edition of Bulletin T-13, "Nickel and Nickel-Base Alloys. . . Their Use in the Design of Corrosion-Resistant Machinery and Equipment," issued by The International Nickel Company, Inc., carries many changes from the preceding one. The text has been enlarged and, for some sections, rewritten extensively; and the tables and curves revised to include the latest available information.

Additions have been made to Tables I and X to include data on the new alloys, Hastelloy B and Inconel R. Tables XI and XVII are brought to date to record the corrosion rates of nickel and monel after five-year atmospheric exposure tests. Several curves have been redrawn and extended.

Power Plant Equipment

Modern equipment for power plants is the subject of an 8-page bulletin recently published by Ingersoll-Rand. Illustrated are such diverse types of equipment as pumps, compressors, condensers, ejectors, blowers, receivers and aftercoolers; also hoists, pneumatic tools and rock drills for maintenance and construction work.

Refractories

A bulletin by the Furnace Economy Company covers its Types "E" and "F" furnace walls and arches for boilers. The offset joints featured by Economy refractories which, the manufacturer claims, eliminate leakage, and other features such as ease of installation, bonding and replacement, are graphically described.

Steam Generators

A 68-page catalog entitled "Steam Generators" has just been issued by Foster Wheeler Corporation. This contains blue-print cross-sections and descriptive matter

on various types of units and numerous halftone illustrations as well as performance figures on representative installations.

Steam Turbines

Information on the application and selection of steam turbines is contained in a new 48-page booklet just announced by the Westinghouse Electric & Manufacturing Company. Covering the seven principal types of turbines in sizes up to 10,000 kw, this booklet presents charts and diagrams that assist in the economical use of steam and production of power.

Large pictorial illustrations, together with cross-sectional views, show typical installations in representative industrial plants. Structural details, such as cylinders, rotors, blades, nozzles, bearings, seals, glands, throttle valves, steam chests, extraction valves and exhaust pressure regulators, are discussed in detail and illustrated by means of diagrams and cut-away views. Four-color charts show the operation of the lubrication system, governor and other control equipment.

Both alternating-current and direct-current generators, as well as exciters and reduction gears, are covered.

Telemetering Device

A new bulletin, No. 194-A, "Bailey Synchro-Meter" is now available from Bailey Meter Company. It presents a simple electrical mechanism which is said to accurately transmit and indicate, record or integrate the measure of any factor, such as flow, level, pressure and temperature at a distant point.

This 16-page bulletin points out that metering equipment operated on this principle has accuracies equivalent to mechanically operated metering equipment; that the device actually operates as a torque amplifier which does not send any reaction back to the transmitter; and that

the system is not affected by any ordinary variations in voltage or power factor. Wiring diagrams illustrating the principle of operation are included.

Water Conditioning in Marine Boilers

Prevention of scale in marine boilers by conditioning the water is the subject of a 24-page booklet issued by Bull & Roberts, Consulting Chemists. After showing that mechanical cleaning of boilers is expensive and that evaporators give uncertain protection, the booklet takes up boiler compounds and their evolution, including the U. S. Navy boiler compounds, and gives the chemical analyses of some twenty-five different commercial compounds which have been, or are being, offered for use in marine boilers. The system of water conditioning advocated in the present publication is based on the theory that those substances whose solubility in water increases with temperature precipitate as sludge when the concentration passes the saturation point, while, conversely, substances whose solubility decreases with temperature deposit as a hard scale. The former class includes carbonates and phosphates.

Water Treatment

Two bulletins, Nos. 285 and 31, have been issued by National Aluminate Corporation. The first deals with the use of "Nalco No. 8" as an anti-incrustant or scale retarder for use in boilers, feed lines, heaters, pumps, heat exchangers, etc., and the second deals with "Nalco No. 21" for the elimination of algae and slime in cooling systems and paper mills.

Zeolite Water Softening

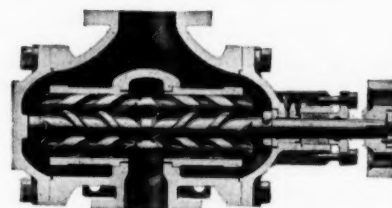
The Permutit Company has just issued a 32-page bulletin, No. 597, devoted to its line of equipment of water softening by the zeolite process. The principles and operation of this system are discussed at length and both diagrams and cut-away wash drawings assist in a ready understanding of how the equipment works. A partial list of applications and typical installation views are included.



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DE LAVAL STEAM TURBINE CO., TRENTON, N. J.

Laying Up Boilers for Protracted Outage

Because of seasonal load, there is more occasion to lay up boilers for protracted periods in the central heating field than in any other. At the recent Annual Convention of the National District Heating Association in New York, the report of the Steam Station Engineering Committee contained a symposium relating to the practices employed by a number of the member companies. Following are excerpts from the report.

In some instances the Philadelphia Electric Company lays up boilers in dry condition and in others they are laid up wet, depending upon the length of time they are likely to be out of service. In both cases the boiler is first thoroughly cleaned and inspected. When laid up dry it is dried out and ventilated; then pans of unslacked lime are placed in the mud boxes or drums and the entire unit is tightly closed. When laying up wet, the boiler is filled to the vent valve, preferably with deaerated water, and during filling, solutions of caustic soda and sodium sulfite are introduced into the feed line. Analyses are made in order to have a pH of not less than 11 and an excess of Na_2SO_3 of between 30 and 40 ppm.

Reporting on practice of the steam heating department of the Detroit Edison Company, A. C. McLellan stated that when boilers are laid up for short periods, or are banked for similar periods, and are therefore filled with water, it has been found advantageous to maintain a pH value in excess of 10 to prevent pitting. To attain this, caustic soda is added when necessary. Occasional analyses are made to see that a free hydrate alkalinity persists. One case was cited where a boiler at the Willis Avenue Heating Plant was out of service for a period of seven years. It was laid up dry and every precaution was taken to assure that it remained dry. To this end all connecting valves were ground in and packed; the manhole plates were left off the drums; the purifiers were painted and closed but opened yearly to make sure they were dry. The boiler passes and furnace were washed and cleaned and care taken to see that no soot remained on the mud drums. After seven years the boiler was put back in service and showed no signs of deterioration.

At the Westport Station, Baltimore, both the dry and wet methods of laying up boilers are employed, depending upon the length of time the unit is to be out of service. The procedure in the former case is as follows:

After the boiler has been drained, and before any work is started for the purpose of drying, an inspection is made to determine whether the stop valve is tight. If there is no leakage past the stop valve, the bonnet is removed from the feed-line check valve to prevent any leakage at that point. Sufficient plates are removed to permit mopping and air-blasting the bottoms of the front and rear headers and drums. As the superheater is self-draining it is necessary to remove only a few plugs to facilitate mopping and air-blasting the inlet and outlet headers. Provision for a natural circulation of warm room air is then made by leaving off three hand-hole plates in the bottom row of the front header, one manhole plate at the rear of one of the drums and three plugs in the superheater outlet header. To prevent foreign matter entering the headers or drums, screened dummy plates are fitted. If after the boiler has been

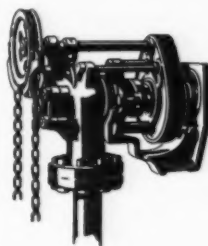
drained, there is evidence of leakage from the stop valve, no attempt is made to lay up the boiler dry until the leaky stop valve has been replaced.

When a unit is laid up wet at this station, the boiler and superheater are filled with water to which has been added sufficient chemicals to give a pH greater than 7 and a sodium sulfite reading of 30 ppm. It is then cut in on a "balance tank" to keep the boiler and superheater completely full. Makeup for the balance tank is supplied by the condensate system. A boiler laid up wet and cut in on the balance tank has a distinct advantage over one laid up dry, as to saving in time and labor required to lay it up and to return it to service.

At the Pratt Street Heating Plant, Baltimore, all boilers are kept available for service during the heating season and during the summer the plant is shut down, but with at least two boilers held available for emergency service.

At the Kips Bay Station, New York, which contains exceptionally large units, when a boiler is taken out of service, the water is drained, the boiler cleaned and overhauled and allowed to remain open until all maintenance work is completed. After this the boiler is refilled with feedwater containing caustic soda and sodium sulfite and given a hydrostatic test. The unit usually goes back in service within ten days or two weeks.

At the Burling Slip Station, New York, after a boiler has been drained and cleaned it is filled with feedwater, containing caustic soda and having a pH of 9 to 10. The boiler may stand by in this condition for several months before being put back in service.



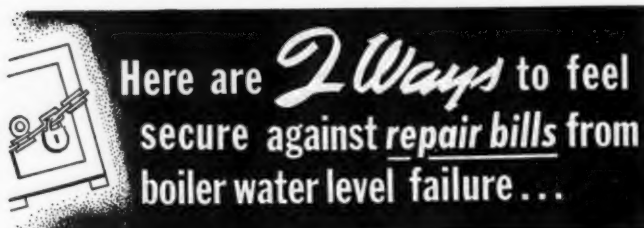
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Advertisers in This Issue

Air Preheater Corporation, The.....	8	Jenkins Bros.....	6
American Blower Corporation.....	4 and 5	Lummus Company, The.....	20
Bayer Company, The.....	48	National Aluminate Corporation.....	22
A. W. Chesterton Company.....	Fourth Cover	Northern Equipment Company.....	2
Cochrane Corporation.....	10	Permutit Company, The.....	17
Combustion Engineering Company, Inc.....		Plibrico Jointless Firebrick Company.....	18
.....Second Cover, 12 and 13		Poole Foundry & Machine Company.....	16
De Laval Steam Turbine Company.....	46	Prat-Daniel Corporation.....	3
Diamond Power Specialty Corporation..	Third Cover	Reliance Gauge Column Company, The.....	48
Edward Valve & Mfg. Company, Inc., The.....	21	Research Corporation.....	9
Ellison Draft Gage Company.....	36	Steel and Tubes, Inc.....	11
Engineer Company, The.....	36	B. F. Sturtevant Company.....	14 and 15
Globe Steel Tubes Company.....	7	Superheater Company, The.....	8
Hays Corporation, The.....	16	Vulcan Soot Blower Corporation.....	47
Ingersoll-Rand Company.....	19	Western Precipitation Corporation.....	9
		Yarnall-Waring Company.....	45



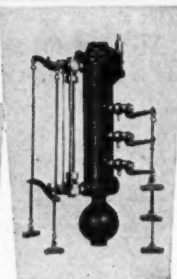
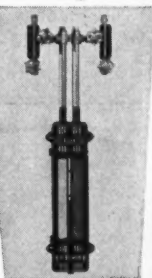
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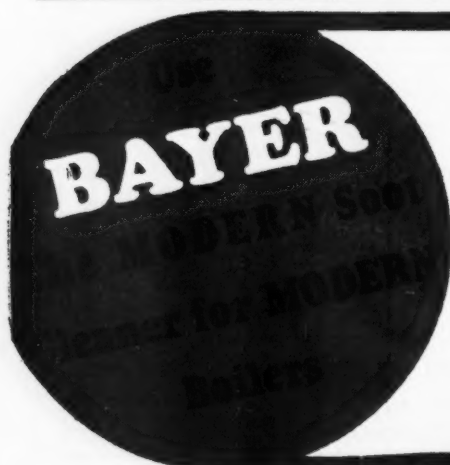
Business Notes

Hagan Corporation has announced the appointment of D. J. Erikson as vice president in charge of sales for Hagan and its subsidiary companies, Hall Laboratories, Inc., the Buromin Company and Calgon, Inc. Mr. Erikson for a number of years has been serving the company in other capacities such as assistant to the president and sales manager of Calgon, Inc., and was formerly sales manager devoting his efforts to the sale of Hagan automatic combustion control.

The National Aluminate Corporation announces the transfer of R. S. Wise from the Chicago area to the South Central States with headquarters at Knoxville, Tenn. T. G. Cocks, formerly at Knoxville, has been moved to Chicago, and R. P. Clausen has been appointed junior engineer in the Philadelphia territory.

Morris E. Leeds, founder and president of the Leeds & Northrup Company, is assuming the position of Chairman of the Board of Directors, and Charles S. Redding, vice president in charge of research and engineering, becomes president, in an expansion of the company's executive setup which became effective July 10.

The Reliance Gauge Column Company announces the appointment of L. C. McKay as an exclusive sales representative for the State of Oklahoma and the Panhandle territory of Texas. He will be located in Tulsa, Okla.



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